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DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GIR/LSY/91D-4

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IMPROVING ROYAL AUSTRALIAN AIR FORCE
STRATEGIC AIRLIFT PLANNING BY
APPLICATION OF A COMPUTER BASED
MANAGEMENT INFORMATION SYSTEM

THESIS

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THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Information Management

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December 1991

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Acknowledgments

This research could not have been completed without the assistance of many individuals and organisations. My thanks go to Lieutenant Colonel Chris Arnold who has contributed his experience, insight, and guidance during my research efforts. Additionally within AFIT, I thank Captain John Borsi for his assistance with the research of routing and scheduling models.

The RAAF's Deputy Director of Movements and Transport, Wing Commander Doug Peak, sponsored this study. With his vast experience and skills, he provided encouragement and critique where needed. I am grateful for his support. Flight Lieutenant Dennis Newcombe also contributed much time and assistance to this research. Additionally, I thank those ADF airlift planners who took time to respond to a long and difficult survey.

HQMAC operations planning staff were most helpful during my investigation of their systems. I am grateful to the time and honest views given to me by the ADANS manager, Lieutenant Colonel Charlie Davis.

For my Canadian research, I relied on the views of course instructors Majors Rick Primorac, Yvan Lupien and John Peverly, who also looked after my wife and me during our stay in Canada.

This study belongs as much to my wife Nikki as it does to me and it could not have been completed without her special contribution and understanding. She provided a laugh when I was fresh out of humour. Lastly, we both thank who ever it is for ensuring our family addition arrived after this research.

Neil A. Cooper

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Abstract

The purpose of this research was to propose a MIS to assist RAAF strategic operational airlift planning. The present manual approach suffers deficiencies in flexibility, consistency and timeliness.

Airlift planning was first analysed and found to comprise activities of investigation, detailed static planning, implementation and dynamic planning, and review. Planning performance is measured by the effectiveness and efficiency of resulting airlift.

Automation of planning functions was investigated, especially the routing and scheduling of airlift. USAF systems, including ADANS, were reviewed and applicability to the RAAF evaluated.

A MIS is proposed that includes six development increments. It is expected to bring improvements in airlift effectiveness and efficiency through improved data management, better communications and improved decision support.

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I. Introduction

Overview

This chapter defines the purpose and constraints of this study and summarises the layout of the research. Terms and abbreviations used within this study are defined in Appendix A.

Motivation

> The message for the 1990's is unmistakable - the performance of the defence portfolio will increasingly be measured against the larger economic and social goals of Australia. Greater efficiency and effectiveness will rightly be expected from all areas of the organisation.
> - Senator Robert Ray, Minister for Defence (Funnell, 1990:1)

This study examines a proposal to improve Royal Australian Air Force (RAAF) strategic airlift planning by application of a computer based management information system (MIS). This application is expected to result in more timely production of airlift plans that are flexible, reactive, reliable and in a form able to be implemented at short notice.

Presently, RAAF strategic airlift planning is performed manually. Recent exercises and contingencies have revealed shortcomings with this approach as each operation required extensive, yet repetitive, data gathering and assimilation. Planning is slow to react and lacks flexibility to adapt to its changing environment (Air Lift Group, 1989:A-1A; Peak, 1990a:17 August; Newcombe, 1990:26 September).

Deficiencies in planning have resulted in ineffective or inefficient application of strategic airlift. Where effective, good

airlift has been largely due to good management of a limited system and not from a well designed system (Newcombe, 1990:26 September).

Application of a MIS to strategic airlift planning will move the ADF closer to a "redundant system that ensures information flow between commanders and their battle forces. Without that system, wastage of airlift can be assumed" (Cassidy, 1986:127). It should provide the timely support required to make more effective and efficient decisions in the airlift environment. Airlift planning reactiveness could improve, allowing commanders more flexibility in the application of airlift to meet operation objectives.

Concurrently, a MIS would provide recording of activities, making data concerning resources, capabilities and capacities more available to the planner. Additionally, actions, achievements and shortfalls would be consistently measured and reviewed. Greater scope for economy and accuracy of effort would result (Mitchell, 1991).

Computers and Decision Making

A computer can not make decisions. All it can do is retrieve, compute and present. Yet, it has potential to impact upon decision making processes by forcing managers to make true decisions in lieu of on-the-spot adaptions. It can "force managers, who have traditionally reacted rather than acted, into genuine decision makers" (Drucker, 1967:159).

The advent of computers has sparked interest in decision making in organisations. This has not been because computers take over decision making but because they take over computation and presentation, forcing

people at all levels of organisations to focus more on learning to be managers and on the making of effective decisions (Drucker, 1966:165).

Management Information Systems (MIS)

> An individual without information cannot take responsibility; an individual with information cannot help but take responsibility.
> - Jan Carlzon, Scandinavian Air Systems (Peters, 1987:609).

Computer based MISs are "integrated human and machine systems for providing information to support operations, management and decision making in an organisation." A MIS goes beyond being a data repository. MIS systems must seek timely ways to assist decision makers of an organisation in the making of their decisions (Ahituv and Neumann, 1990:129; Davis, M., 1988:4-5; Cook and Russell, 1989:699).

The requirement that a MIS directly supports decision making processes is important to this research. While computer systems have been employed to produce airlift planning documentation in the Australian Defence Force (ADF), there has been little application of computer based information to assist in the decision making process of the airlift planner. Though the production and reproduction of results of planning is important, a MIS to support strategic airlift planning should be primarily involved in assisting decision making (Peak, 1990a:23 August; Mitchell, 1991).

Decisions can be categorised, according to Simon's classification of decisions, as structured, unstructured and partially structured. The distinction between completely structured and unstructured decisions is based on certainty of action, though in reality all decisions fall within a continuum bounded by the structured and unstructured types. A MIS assists users in all categories of decisions through two types of

logical components; a structured decision system and a decision support system (Ahituv and Neumann, 1990:129).

Any MIS, to support the strategic airlift planner, would be expected to make structured decisions based on an algorithm and data. This frees the airlift planner to consider more unstructured and complex decisions. With these decisions, a MIS would apply heuristic methods and models to represent the decision environment. Through recommendations and evaluation of options, it would support the airlift planner in making the best choice in the required time frame with the available data.

Purpose of Study

This study analyses how a computer based MIS can improve RAAF strategic airlift planning.

Investigative Questions

The following questions were investigated during this study:

1. What constitutes the planning function of strategic airlift?
2. What factors affect strategic airlift planning?
3. What are the indicators that allow airlift planning effort to be evaluated and how are they measured?
4. How is strategic airlift planned by the RAAF?
5. How is strategic airlift planned by other defence forces?
6. Are there ways of automating problems of routing and scheduling?
7. What systems development methodology should be used to design the MIS?

8. How would a RAAF computer based strategic airlift planning system operate?

Scope and Limitations

This paper aims to establish that a computer based MIS to support RAAF strategic airlift planning is both feasible and advantageous. A MIS is proposed after study of existing approaches. Development of the system is not intended during this research effort. This would be premature as the RAAF has no plans to implement such a system.

However, some development is required to validate claims. A high level design is used for overall testing. Where critical system concepts demand more rigorous validation, there is detailed design and prototype development.

Though there are no firm plans to implement a strategic airlift planning MIS, the sponsor of this research, the Deputy Director of Movements and Transport, advises that such commitment is likely "in the near future" (Peak 1990a:17 May). Consequently, he has requested that any development effort be in a form useful to the RAAF should it make a commitment to implement a strategic airlift planning MIS.

This implementation stance has affected this research. The likelihood of implementation has encouraged effort to be directed towards areas that have immediate and direct application, instead of precise but theoretical models. All the same, lack of commitment reduces usefulness of research of implementation issues. Therefore, implementation issues are discussed, with less detail than required for actual implementation, after the primary research.

With sponsor concurrence, wider organisational issues, such as power and politics, are not addressed. Though these issues form part of normal MIS design, this choice bounds the research. It also avoids undermining principal findings of this research by involving readers in emotionally charged issues such as influence, referent and coercive power and organisational manoeuvre.

This thesis is unclassified. While security restrictions caused few problems for the bulk of the research, complications arose during quantification of the RAAF system, research of procedures of other countries and the testing of the proposed system for airlift planning. Because actual airlift data is classified, data had to be reviewed to declassify data concerning capabilities and events. While endeavouring to maintain consistency in size, scope and application of data, this filtering process could open the findings and comparisons between proposed and actual performance to bias. This is unavoidable.

Assumptions

It is assumed that the ADF scenario will not significantly depart from strategies of defence in depth, self-reliance and the defence of the north of Australia.

Further, it is assumed that ADF exercise scenarios and activities are reasonable representations of the demands that would be placed upon an airlift planning system in times of contingency and emergency.

Given these assumptions, ADF exercise data can be used for system validation and design.

Organisation of Study

This study is presented in eight major sections. Chapter I introduces the research by outlining the reason for this study. Chapter II gives background to Australia's defence system, the air mode of transport, airlift and strategic airlift planning. The methodology used for research is described in Chapter III. Chapter IV examines airlift planning by reviewing how it is planned by the ADF and the military of other countries, and examines those factors that influence and measure airlift planning effort.

A MIS development methodology is expounded in Chapter V and then applied to propose a MIS for use in RAAF airlift planning. The effect of this system on RAAF strategic airlift planning is also analysed.

Validation of claims occurs at Chapter VI, with the proposed system and a prototype used as test beds for verifying feasibility and improvement. Chapter VII considers implementation issues as an adjunct to the study. The conclusions and recommendations which result from this study are detailed in Chapter VIII.

II. Background Discussion

Overview

This chapter investigates the factors which affect strategic airlift planning. It provides background to airlift in the ADF and an overview of the strategic airlift planning process.

After introducing the ADF, the chapter describes strategic airlift, the role of airlift within the ADF and the responsibility of the RAAF to conduct strategic airlift operations. The chapter then introduces strategic planning by discussing the principles of airlift planning and the factors involved in the planning process.

The Australian Defence Force and the Defence of Australia

Australia is a large resource rich island nation surrounded by extensive oceans (Dibb, 1990:16). Natural barriers and a stable region make it one of the most secure countries in the world. Its population, approaching 17 million, is concentrated in the southeast, leaving much of the country's 7.68 million square kilometres sparsely populated.

However, "it would not be prudent to assume that Australia will always be able to conduct its affairs without challenge" (Dibb, 1986:1). So, the Australian people have charged the Government with the responsibility of providing the requisite power to defend itself from attack and "from the constraints on independent national decisions imposed by the threat of attack" (Department of Defence, 1989:ix).

The ADF has the objective of planning, developing and maintaining forces for contingencies within Australia's area of direct military interest (Department of Defence, 1988a:1). Currently at about 70 300,

the ADF is small considering its land coverage and responsibilities. Operationally, it is comprised of a Headquarters, Navy, Army and Air Force. The full time all volunteer force is supplemented by a reserve force numbering 39 800 (Department of Defence, 1989:6,8).

A 1987 Government White Paper established a blueprint for future ADF planning. The paper identified the expected levels of conflict that the ADF could be involved over the next ten years and set a requirement for "the force-in-being to be able to meet low level contingencies ... and be able to expand in a timely fashion against the prospect of a more substantial threat emerging" (Dibb, 1990:16).

Additionally, the defence review provided the ADF with the priority of an independent capability to defend Australia through skilled application of technology that multiplies force capability. Meeting this requirement also provides the Government with practical options to use elements of the ADF in peacetime tasks in support of its people, regional friends and allies.

In line with the review, the ADF has adopted a strategy of defence-in-depth. This concept requires the capability to conduct operations including: surveillance and patrolling throughout Australia's immediate maritime approaches, maritime strike and air defence to intercept adversaries during their vulnerable transit phase, and mobile rapid ground force reaction to defeat hostile incursions at remote locations and protect civil and military infrastructure (Dibb, 1990:17).

Self-reliance and operations of forward patrol and strike have placed greater emphasis on the logistic support of deployed forces. Part of this logistic support is the timely transport of a force and its

maintenance requirements from normal locations to locations required for operations.

Movement Support of the ADF

"In peacetime, the movement requirements of the ADF are ... small and encompass regular movement of personnel and materiel for routine support within Australia and overseas" (Department of Defence, 1988b:10). Yet, in times of operations, major defence exercises or national emergency, the large scale movement of personnel and materiel extends transport resources.

There are five modes of transport available to move personnel and materiel: air, water (sea and inland), road, rail and pipeline (Department of Defence, 1988b:31-32). Though the movement of a force is collectively managed at a centralised and high level, responsibility for modal transport is usually delegated to a single service to manage.

A strategy of deterrence through forward defence requires a rapid deployment capability. For deterrence to be effective, Australia must be capable, and seen as being capable, of responding promptly to aggression. A creditable deterrent hinges on the ability to deliver forces rapidly to trouble spots and sustain them once employed. The air mode's advantage of timeliness makes it critical to Australia's deterrence stance.

Further, "ground forces are being prepared to meet contingencies at lower levels, which are more creditable and have shorter warning time" (Dibb, 1986:55). At this level and given Australia's geography, opposing forces would be expected to swarm dispersed elements, strike and then scatter (Skorupa, 1989:43). Surface lines of communication

would be subject to sudden and unpredictable attack. To compensate, airlift would be the primary means of reliable resupply. History shows that "airlift is the only means of sustainment for ground forces whose whole lines of communications are temporarily cut" (Cassidy, 1986:124).

Strategic Airlift

ADF responsibility for strategic airlift is vested in the RAAF (Department of Defence, 1985:14-1). Strategic airlift is the movement, by air, of personnel and stores from a support area to an area of operations (AO), between AOs or to another support area. Its application is directly supported by six of Australia's principles of warfare: offensive action, surprise, concentration of force, economy of effort, flexibility and administration (Royal Australian Air Force, 1990:65,158).

Airlift enhances a battlefield commander's concentration of power against what "Clausewitz called an enemy's centre of gravity - the focal point against which all military energies should be expended" (Cassidy, 1986:124). It provides advantages of flexibility, swiftness of application, ubiquity, range and political responsiveness. Air assets can be quickly and effectively diverted between tasks and can be employed in different roles with minimum difficulty. Through its characteristic of speed, strategic airlift is ideally suited to demonstrate a nation's political intent by immediate action or capability to act. The speed and endurance of modern strategic transport aircraft allow airlift to cover long distances without constraints of physical barriers (Royal Australian Air Force, 1990:156).

Limitations of airlift include cost, dependence on air bases and impermanent effect. The cost of airlift flight time is high, aircraft numbers are limited, aircrew cannot remain on duty indefinitely and the effectiveness of airlift is lost if there is insufficient infrastructure to support aircraft. "Consequently, the system of preparing, ordering, loading, and unloading of people and cargo must be designed for flexibility, smooth operation and simplicity" (Royal Australian Air Force, 1990:157).

RAAF Airlift Resources

Through its Air Lift Group (ALG), the RAAF operates two large capacity strategic airlift aircraft, the Boeing B707 and the Lockheed C130. Both aircraft types are based at RAAF Base Richmond, New South Wales. The RAAF operates six multiple configuration B707s. The RAAF's 24 C130s include equal numbers of "E" and "H" models. Though the C130 models have different roles and characteristics, they share responsibility for strategic airlift.

ALG also manages the direct airlift support needs of the ADF, including crewing, loading and turnaround of aircraft. It calls on other agencies of the RAAF and ADF to provide airlift support through extended aircraft overhaul, air traffic control, catering for airlift, airfield security and general logistics support.

Besides providing airlift though its own aircraft and infrastructure, the RAAF relies strongly on civil sources of aircraft and capability. Despite restrictions of cost, control and safety, the Australian Government has encouraged the use of civil airlift to supplement the strategic lift capability of the ADF. Importantly, the

application of airlift resources is subject to the same planning processes whether military or civil sourced.

Civil airlift can be acquired by "buying space on regular services [usually seats], chartering an aircraft for a specific time or task, or enacting legislation to direct a service to be provided" (Department of Defence, 1988b:35).

Airlift Planning

The RAAF is responsible for planning and controlling aspects that form part of an airlift system. The importance of planning airlift is evident in the advantages that effective airlift provides. The limitations demand exactness in planning and accountability of action.

The speed of airlift and its reactiveness, compress the time available to plan its effective and efficient use. Effectively linking the disparate requirements of precision and timeliness is the aim of airlift planning systems. Airlift planners are constantly seeking ways to improve the marriage of these inconsonant bedfellows.

Principles of Airlift Planning (Department of Defence, 1988b:10-11)

There are four interdependent principles of movement that can be applied to airlift planning. These include:

1. Movement management must be centralised at the highest level.
2. Movement must be regulated.
3. Movement must be fluid and flexible.
4. The maximum utilisation must be made of carrying capacity.

Centralisation optimises the use of scarce resources by allowing the massing of resources and directing resources to the tasks with the highest priorities across the ADF. Regulation of movement avoids

congestion in the airlift system, and achieves an even and reliable flow.

Applying regulation and flexibility to planning allows demands of special urgency to be met with certainty. Additionally, flexibility provides for breakdowns and unplanned surges in demand. By eliminating congestion points and spreading tasking evenly, sufficient reserve can be provided in resource and network capacity to meet these unexpected arisings. Yet, unnecessary or excessive non-committal of resources must be avoided as planners should strive to maximise the utilisation of carrying capacity.

Factors in Airlift Planning (Peak, 1990a:14 March)

Of the transport modes, airlift requires consideration of the most factors. Factors can be grouped according to their sourcing into commitment and resource.

Commitment Factors

Commitment factors are peculiar to that which is to be moved, usually termed the bill. These include:

1. size and characteristics,
2. departure and destination requirements,
3. the order of march,
4. integrity requirements,
5. movement availability windows, and
6. notice of requirements.

Size and Characteristics. The size of the force to move affects the airlift planning effort. Additionally, the composition of the force and its objectives affects the priority and hence resources it receives.

Departure and Destination Requirements. Varying according to the characteristics and scope of the operation, the number of departure and entry points (POD and POE) range from one to many of each, though numbers rarely exceed about ten destination points and 20 departure points. Though the definition of PODs and POEs would normally follow from a force commander's requirements, their impact on the capability of airlift is significant enough for them to often influence the higher scenario for operations.

Order of March. The order of march is "the order in which forces deploy to, within, or redeploy from, an area of operations" (Department of Defence, 1988b:14). The order usually specifies the unit component, POD, POE and movement window. The ordering of movement usually restricts the flexibility available to the airlift planner in maximising utilisation. A force commander defines the order of march in conjunction with his executive movement planning staff. Each modal planner usually receives the order of march for components of the force assigned to each mode for transport. While the airlift planner aims to meet the air mode order of march, higher level movement planning staff must ensure that the cumulative modal planning effort meets the total order of march.

Integrity Requirements. For reasons of engagement soon after arrival, administrative control or shortages of support equipment, the consolidated movement of some groups within the order of march is often enforced. Though this approach is supported by normal airlift planning principles, some restrictions on the maximisation of utilisation result.

Movement Availability Windows. Part of the order of march statement for each component of a force is a definition of the period

from when the component is first available to move and when it must have moved by. The grouping of sub-units around time periods, the relationship between advance and main body movements, the width of acceptable movement windows, overall movement period and the impact of movement decisions of one group on other windows are aspects of the movement time requirements that affect airlift planning.

Notice of Requirements. Changes in scenarios and arisings during operations often dictate changes in a force commander's movement requirements and priorities. As air is usually the most responsive mode, requirements are often presented to the airlift planner with little notice and requiring near-immediate decisions.

Resource Factors (Department of Defence, 1988b:31)

Resource factors include:

1. airframe availability,
2. crew availability,
3. crew endurance,
4. flying time,
5. payload availability,
6. supporting services,
7. aerodrome restrictions, and
8. environmental considerations.

Airframe Availability. The small fleet size and specialist configurations of some airframes, especially B707s, forces the airlift planner to consider airframe disposition. To meet concurrent requirements by multiple planning agencies, planners are often allocated a maximum number of airframes of each type.

Crew Availability. ALG aircrew numbers, though adequate, demand planning to ensure there are sufficient crews to meet tasking. Aircrew are qualified to airframe type and model. So, though airframes may be available, qualified crews may be unavailable to perform the task, while other aircrew are idle. Some tasks require special qualifications of crew members which restricts the planner's flexibility in dovetailing tasks, especially when changing tasking already under way.

Crew Endurance. Australian aviation safety regulations dictate that the duration of crew tasking be strictly limited and include minimum rest periods between tasking. Increases in availability can be gained by application of augmented and slip crews.

Flying Time. Resources available to the RAAF airlift planner have traditionally been defined in units of hours of each aircraft type. Hours committed to a task is a factor of distance between way points, aircraft cruise speed, and task type. Though allocating resources by type restricts the freedom of the planner to make the best economic decision, it has been adopted as a convenient and simple way to bound resources available and reduce over-commitment of airframes and crews.

Payload Availability. The payload availability of an aircraft on a task is critical in allocating enough resources to meet requirements and maximising utilisation. It is a factor of aircraft type (including maximum weight, door limits, floor limits and seating limits), individual airframe characteristics, flight time, fuel reserve requirements per leg, loading equipment and task restrictions such as over water flights and landing weight maximums.

Supporting Services. On-ground restrictions on airlift are often overlooked. They include refuelling, maintenance, and loading

considerations. Refuelling capability addresses correct type and system and sufficient volume for the numbers and types of planned aircraft. Scheduled maintenance is usually done at a dedicated site and requires planning to avoid congestion of airframes at facilities. Loading facilities at departure and destination airfields restrict the type and weight of payload and the turnaround time for aircraft.

Aerodrome Restrictions. Because of aerodrome location, construction, facilities and primary role, aerodrome management often impose limits on airfield use. Restrictions in landing and take off weight and numbers are used to minimise damage to runways, while hours of operation restrictions apply where night facilities are not available or primary operations may restrict military operations. Taxiway and parking limits restrict the numbers and types of aircraft allowed on ground at any or defined times. Payload type restrictions may limit the carriage of dangerous cargo or uncleared passengers to or from an airfield.

Environmental Considerations. Despite considerable advances in capability of aircraft, weather still affects airfield availability and transit times. Theatre and tactical air supremacy or parity are also considerations in the planning of airlift.

Summary

Airlift is at the heart of Australia's strategy of defence in depth. It provides the essential mobility to project military power from remote areas. It enhances combat power by allowing a degree of manoeuvre otherwise impossible in many areas of Australia, where difficult topography severely hampers surface transport.

Such mobility, achieved by very limited resources, demands expert control. Detailed planning is required to derive the mix of resources that will meet requirements and satisfy restrictions.

III. Research Methodology

Overview

The primary goal of this study is to determine how computer based information management can be applied to improve strategic airlift planning. This goal was achieved by first investigating airlift planning approaches and algorithms to solve complex routing and scheduling problems. A MIS was then designed to assist airlift planning, based on a methodology developed through research.

This system was compared with the current RAAF planning process by analysing the performance of both with similar data and requirements. This comparison formed the basis of a discussion of results, issues, recommendations and conclusions.

The findings of this study are intended for direct application by the RAAF. Therefore, important goals of this study were that any proposed system be based on recent RAAF airlift scenarios and any claimed system advantages be substantiated. Additionally, it was beneficial that any proposed system be easily implemented and any systems development effort conducted in this study be useful in the development of a system for the RAAF.

After recognising a preliminary analysis, this chapter presents a discussion of the phases of the research. Research methods applied for each phase are examined by looking at issues of administration, selection, development and interpretation. The second section provides more detailed discussion of the sources of information used in this research.

Preliminary Analysis

Critical to this study was a finding that the present system suffered sufficient deficiencies to warrant consideration of change. Though personal experience of the author and sponsor suggested that deficiencies certainly existed, the criticality of this premise demanded that a pilot study be conducted before embarking on the main research.

Low level electronic storage of airlift planning data was introduced during an ADF exercise. Though only a crude data management system, this approach produced benefits and suggested that scope for much greater improvement existed through automation.

Lastly, informal discussions were conducted with personnel involved in the exercise. Despite some reservations concerning design issues such as security, control, access and management, all agreed that automation of airlift planning would "certainly improve the way we do business and raise our level of service to our customers" (Thomson, 1990).

Executive management endorsement of this study occurred in February 1990, allowing data collection whilst in Australia and approval of visits to other countries.

Specific Methodology

The research was conducted in seven phases:

1. The investigation of airlift planning concepts and systems.
2. The selection of a systems development methodology.
3. The development of a proposed system.
4. The testing of the system.

5. The demonstration of variation in planning capability between the present and proposed systems.

6. An overview of the likely implementation issues; and

7. The making of conclusions and recommendations.

Phase One: Investigation

In the first phase of research, the airlift planning process was analysed through the following investigative questions:

1. What constitutes the planning function of strategic airlift?

2. What factors affect strategic airlift planning?

3. What are the indicators that allow airlift planning effort to be evaluated and how are they measured?

4. How is strategic airlift planned by the RAAF?

5. How is strategic airlift planned by other defence forces?

6. Are there ways of automating problems of routing and scheduling?

Questions 1-2: What constitutes the planning function of strategic airlift and what factors affect it?

For the Chapter II discussion, ADF literature addressed what comprised the RAAF strategic airlift planning function and which general factors affected airlift and hence its planning effort. Literature was reinforced by opinions of ADF personnel.

Question 3: What are the indicators that allow airlift planning effort to be evaluated and how are they measured?

Defense Technical Information Center (DTIC) sources were searched for studies of airlift capability assessment and measurement. Several studies were found that attempted to apply force capability delivered as a measurement. Dialog Information Services (DIALOG) sourced indicators

used by civil operators, but these were not found applicable, given the different operating motives.

ADF literature provided the broad measures of effort. Interviews with ADF personnel and 26 survey questions sought greater clarification of quantifiable measures. Planning staff at Headquarters Military Airlift Command (MAC) clarified the different methods used by the United States Air Force (USAF).

Question 4: How is strategic airlift planned by the RAAF?

ADF publications provided the division of responsibilities for airlift within the ADF and definitions of terminology. Reviews of recent and indicative airlift activities provided the data required for analysis of the quantities and capacities.

Initial research confirmed the author's awareness that planning of airlift in the ADF is largely an undefined function. Consequently, the greatest source of information was from the views of those personnel responsible for airlift planning over the last five years.

Information was obtained from 19 ADF personnel by interview and survey. Opinions were sought on what factors affected airlift planning and to what degree, what constituted good airlift planning, the effectiveness of planning efforts, and the potential for computer based information support. Deficiencies in the present system were also targeted. ADF exercise data provided quantification of the present systems capabilities and problems.

Question 5. How is strategic airlift planned by other defence forces?

The world is full of organisations that plan airlift. Unfortunately, time restricts this research to only one or two that

offer the most insight into airlift planning for the ADF. The United States military was investigated because it employs sophisticated automated airlift planning systems. The Canadian National Defence Force (CNDF) was studied because of similarities in size, airlift resources and planning approach to the ADF.

The USAF plan airlift with assistance of computer systems. During the research period, MAC provided airlift management for Operation Desert Shield/Storm, a multi-nation contingency. This provided an excellent opportunity to evaluate recently introduced systems. Personal interviews at MAC, after the main airlift phase had been completed, gained assessments of the performance and usefulness of systems. Interviews were conducted with planners, systems designers and peripheral "players". Hands on access to systems under consideration and access to system documentation provided extra information.

Small scale airlift planning systems used by the USAF and United States Army were also investigated. Systems, were targeted in searches through DIALOG and DTIC. Where systems appeared promising, sample copies of software were obtained through the Air Force Logistics Management Center at Gunter Air Force Base.

The CNDF relies on manual planning of airlift (Peverley, 1990). A course, offered by the CNDF in April 1990, provided insight into Canadian airlift planning practices. Personal interview with teaching staff from that course provided additional information.

Question 6. Are there ways of automating problems of routing and scheduling?

For the Chapter IV discussion, DTIC located previous research concerning routing and scheduling of airlift, principally for the United

States military. AFIT staff directed pure research into classical routing and scheduling problems, their time and space complexity and their algorithmic solution.

DIALOG produced International Aerospace abstracts of applied research concerning the routing and scheduling of commercial cargo and passenger aircraft. Upon advice from AFIT staff, this search was expanded to include operations research studies in other areas.

Phase Two: Selection of Systems Development Methodology

In Chapter V, a systems development methodology was selected after reviewing literature concerning systems development activities and traditional methods and tools. Information on recent trends and tools was found in journals and periodicals, bridging the gap between pure and applied discussion of methods and results.

Aspects of the strategic airlift planning environment impacting the choice of a systems development methodology were deduced from the literature and through interview with AFIT specialists. Assessment of impact required measuring of the size, complexity and frequency of those aspects through the analysis of exercise data and post exercise reports and ADF personnel by interview and quantitative responses to a survey.

The aim that the development effort be useful to future RAAF efforts affected choice of design methods. It encouraged selection of proven tools, techniques and platforms that were supported by reliable vendors. Expectations of longevity of vendors and their products was also considered. Industry journals and newspaper articles were used to gauge strength of products and vendors.

Preference was given to analysis and design techniques and tools that were in use in the ADF. RAAF automated systems policy makers are

encouraging use of standard approaches to systems development. They consider that this is likely to reduce effort expended in transfering results between systems (Tyrrell, 1991). ADF staff provided an indicative list of the types of products in use in the ADF.

Database relation and element definitions were maintained in a design database. This allows ready transfer of data between systems and techniques should this be required after the study. Additionally, this activity provided the author with hands on exposure to selected software and made data definition maintenance more manageable.

Phase Three: Development of System

Having developed a methodology, phase three involved its application to the design of a MIS system for airlift planning. System requirements and performance minimums, deduced from findings of the investigative phase, were endorsed by the sponsor of the research and by other ADF personnel.

Development included three components; overall configuration design, definition of primary system components and development of a prototype of phase one of the system.

Configuration design was supported by literature recommended by AFIT specialists. Rigorous explanation and evaluation of concepts was provided by texts, while articles addressed issues of connectivity, developments and performance.

The chosen method required development of those system components that were critical or produced most return on investment. Survey findings directed the choice of components. Results of the development, using the selected methods and tools of design, is presented at Chapter V.

Phase Four: Testing of Proposed System

The development method called for specification of system goals and requirements. Formal a priori definition of goal attributes, included measures and scales of performance. The proposed system was tested against these goals.

Overall feasibility of the system could be tested in this way. More detailed development and deeper testing was considered necessary for critical components of the system. Consequently, detailed definitions and a prototype were developed for these components. This greatly improved confidence in accuracy of test and validation results. Discussion of this deeper development occurs at appendices referenced by Chapter V.

Past ADF exercises provided quantitative data needed to define and verify the logical design and prototype produced. This allowed the system to be developed based on various realistic airlift scenarios and levels of resource commitment.

The system was tested using a large scale exercise. This tested all components of the system and placed a heavy load on the prototype, both useful to testing. A small scale exercise was applied to the system to provide some test of feasibility with a different scenario. This allowed design limitations, resultant from the application of one exercise and scenario, to be removed before evaluation.

Phase Five: Demonstration of Planning Capability Variation

Having developed the system to a testable stage, the sponsor was invited to participate in validation. As well as introducing independence into testing, this allowed input from the sponsor to other stages of the research.

Before departing Australia, the sponsor was invited to define the criteria by which the feasibility and potential advantage of the system would be judged. Additionally, he was invited to bring extracts from an airlift exercise or operation. This approach improved quality of validation by evaluating correctness of systems goals and measurements and reducing bias caused through author choice of test bed.

Present system performance during the extract period had been recorded. Performance measures included timings and shortcomings. The sponsor would then attempt to apply the same extracts to the proposed system.

The overall system design was first presented to the sponsor. For each event sequence, capabilities of the system and the improvements offered were discussed. After discussion of all event sequences, the sponsor provided additional comments, including improvements where required. The sponsor's evaluation of the system's feasibility and potential formed the basis for the Chapter VI discussion.

Next, the critical components were considered in more detail. The aim was to extract more quantifiable measures of improvement in the essential and primary components of the system. The prototype was loaded to represent the airlift state prior to each time sequence. The sponsor was then presented with the log and other scenario data pertinent to the sequence and requested to action the log using the prototype.

Using the sponsor to perform the test allowed other issues, such as user friendliness, to be adequately tested. Times to perform transactions were measured and sponsor reaction recorded. This continued for each sequence that addressed the prime components.

After testing, sponsor opinion was extracted through unstructured interview. Quantitative results were tallied and averaged. Where time savings had occurred, the potential saving during a complete operation was deduced through extrapolation. This data formed the quantitative support for the Chapter VI evaluation of the prototype.

Phase Six: Implementation Issues

As previously discussed, implementation issues were not addressed in the main part of the research. Consequently, claims were not validated. However, this choice obliged the author to refrain from making specific claims concerning implementation in the Chapter VI discussion.

Literature, recommended by AFIT staff, provided information on implementation issues. Discussion of issues peculiar to the potential implementation site, the RAAF, was based on perceptions of the author and ADF personnel. ADF personnel opinions were gleaned through personal and telephone interview and a survey question.

Phase Seven: Conclusions and Recommendations

In the final phase of the study, conclusions were drawn and recommendations made on implementation of a MIS to support strategic airlift planning.

Information Gathering

Information was sourced in three ways; review of literature, solicited views of experienced people and extraction of data from past ADF airlift operations.

Literature reviewed included pure and applied research, works defining doctrine, and operating guides, manuals, and regulations.

DTIC, managed by the Defense Logistics Agency, provided previous United States military research and doctrinal studies. ADF airlift planning staff, AFIT staff and the DIALOG sourced additional literature concerning computer aided airlift planning systems, the automation of routing and scheduling problems and development of computer based systems. DIALOG, a retrieval service available to the public, searches the Compendex Plus data base which contains extracts of journals, periodicals, newspapers and newsletters.

ADF literature was sourced from the author's professional military and specialist knowledge and that of RAAF officers responsible for airlift planning policy. Manuals and additional systems literature for other countries' systems were located after advice from personnel responsible for control or application of these systems.

Solicited views of experienced people provided information about the factors affecting airlift planning, the measurement of planning effort, and procedures for planning. Senior officers, managers and non-commissioned staff responsible for planning effort, performance of present systems and the implementation, distribution and achievement of airlift plans were targeted.

Additionally, aircrew who flew airlift tasking, ADF liaison staff representing the force lifted, and other specialist military staff with recent exposure to airlift planning and implementation efforts, provided information.

Because of distance, personal interviews of ADF personnel were not possible. Consequently, views were obtained through a combination of telephone interviews and written surveys. Personal correspondence was

sought from the sponsor and other key individuals. Telephone interviews used an unstructured and opinion seeking approach.

Survey of ADF Personnel

Surveys were tailored to the speciality skills, experience and present duties of respondents. The full survey instrument was divided into sections based on respondent employment category and exposure to airlift. The full survey instrument is attached at Appendix B.

The survey instrument for each respondent was assembled by the combination of applicable sections of the full survey, under cover of a standardised introductory section. This introductory section provided background to the survey, defined terms and solicited information concerning respondent identification and experience.

Unfortunately, a long survey was required to address all issues in sufficient detail. This was expected to affect the quality and number of returns. However, alternatives of follow up surveys and personal interviews were rejected because of impacts of time and distance. Personalised and motivating correspondence covering the survey and telephone contact were used to achieve respondent interest and a reasonable rate of return.

Surveys sought both opinion and fact, using open ended and multiple choice question formats. Nineteen open ended questions gathered data and expressions of opinion. Forty six multiple choice questions required respondents to rank support of answer options. Expression of opinion was also available in the multiple choice questions. Where respondents had access to airlift statistics, the survey requested useful statistics.

Classic scientific analysis sampling methods were not used. Usual research practice would seek a random selection of respondents, from the population of all ADF personnel with exposure to airlift planning effort, to reduce incidence of bias in the opinion gathering process. However, while exposure to airlift activity is not uncommon among ADF personnel, there are few with good exposure to airlift planning activities, especially all levels of command and dealing with a variety of scenarios. Those few are well known within a small force like the ADF. So, information gathering targeted those few with exceptional experience.

The survey instrument was tested locally and forwarded to the sponsor for appraisal and acceptance. Twenty-eight surveys were forwarded to ADF personnel ranging from senior to non-commissioned officers. Sixteen responses were received, giving an acceptable response rate approaching 60 percent. Some respondents commented on shortcomings in the survey's design.

Data from Airlift Planning Activities

This research also required detailed quantitative data to assist in design and testing. This data was sourced from previous ADF airlift planning exercises. The choice of which airlift efforts would represent the population of all ADF airlift had potential to introduce bias.

To minimise the incidence of bias in test data selection, the sponsor was approached, at commencement of this research, to provide exercise data that could be later used to test and evaluate any proposal. Airlift planning data on two exercises was provided.

One exercise involved large scale and complex airlift planning of military and civil resources. It was conducted in 1989 and was the

largest airlift of the ADF since World War II. It was a rigorous test of the ADF's airlift planning capability as it included significant deliberate and unexpected events which tested airlift planners, including a major civil emergency requiring military airlift support to the nation (Air Lift Group, 1989:3).

Data gave a before and after shot of the planning process. It included the requirements or lift bill, the airlift initial plan and the post exercise evaluation of the performance of airlift. Additionally, time slices of the airlift plan at various stages of its development, implementation and modification were available. An exercise log provided a description of the planning environment. Exercise data was captured on electronic and longhand medium.

The author and sponsor had been responsible for the airlift planning for the exercise. Recognising that greater independence of results would occur if testing used data of an exercise unknown to the author and sponsor, attempts were made to locate data pertaining to other exercises. However, deliberate efforts had been taken on the larger exercise to record all events. This was not the case for other exercises.

Other exercise records did not contain sufficient data to present a complete description of an airlift planning operation. There were no logs of activities, no planning work sheets or other documents that provided complimentary data to the airlift planning process. While testing the general capabilities, the independent exercise could not reliably and exhaustively test the system.

For other exercises to be useful, indicative scenario and other contributing factors would have to be injected into testing. Overall,

this process had the potential of introducing more bias into testing than it avoided. Additionally, data was only available in longhand form, which would have extended time requirements of the testing phase.

Therefore, the larger exercise was chosen as the main test bed for this research. The smaller exercise was used to develop the system and test feasibility. To improve testing validity, the sponsor was requested to specify which periods and activities of the exercise to base validation upon. The author was not advised of this choice until testing began. Though this introduced some overhead to load the prototype to reflect the state needed, it provided independence.

For the larger exercise, the author had been responsible to the sponsor for the detailed airlift activities of the exercise. As the sponsor had been involved, at an executive level, he had good recollection of those factors present during the exercise. Yet, as he did not do the airlift planning, he was not aware of most detailed airlift decisions made at the time. Additionally, having been part of the airlift executive during the exercise, the sponsor was aware of the requirements of executive management of an airlift planning MIS.

Using sponsor chosen extracts from the large exercise allowed the author, as tester, to have good recollection of the activities being reproduced without being involved in selection of the test period. Yet, the tested, to whom the prototype was new, chose what activities to base the test upon without being aware of the detailed airlift planning activities undertaken during the actual test period.

An additional advantage of this approach was that the sponsor was free to define what activities were prime parts of the airlift planning process. This improved the quality of validation.

Summary

This chapter discussed the research methodology used in this study by first looking at the specific aspects of the six phases of research. General issues of data analysis and information sourcing followed.

The first phase investigated airlift planning in the RAAF, USAF and CNDF. Theoretical and empirical studies of routing and scheduling methods were also investigated. The next phase researched and developed a methodology to develop a MIS. In phase three, a MIS was designed to assist in RAAF airlift planning, though full development of the system was not possible or required. In phase four, this system was tested against current RAAF airlift planning processes by analysing the performance of both with similar data and requirements. Phase five continued testing by addressing the improvements claimed by the proposed system. Secondary research was conducted into likely implementation issues in phase six. Recommendations and conclusions comprise phase seven of this study.

IV. Airlift Planning

Overview

This chapter investigates the airlift planning process. Investigative questions concerning the planning function, its measurement and automated support, and approaches of various military forces are addressed. The chapter aims to guide later proposal of a RAAF airlift planning MIS by defining the planning environment and gauging the effectiveness of computer based airlift planning systems.

The chapter starts with a discussion of airlift planning concepts by looking at planning activities and mapping them to overall operation milestones. Theoretical and automation issues are then discussed.

The RAAF airlift system is analysed in detail. Factors of good planning and their measurement are discussed as well as deficiencies in the present approach. An overview of airlift planning approaches employed by the USAF and CNDF follows. Any use of automation in planning is discussed, as well as similarities in approach, different performance measures and similarities between systems.

Airlift Planning Concepts

Cost minimisation is the primary objective of most distribution problems (Bodin et al., 1983:79). However, in military airlift operations, cost cannot be the primary consideration because survival is at stake (Department of the Air Force, 1985:3-2). "Any military weapon system must be effective first with notions of efficiency and economy being subordinate" (Mitchell, 1991). Still, efficiency is important to

the extent that it contributes to combat effectiveness (Department of the Air Force, 1985:3-2).

The aim of all airlift planning is to put the right force in the right place at the decisive time (Cassidy, 1986:114). Given a feasible airlift scenario, there is an available optimal solution or solutions. However, time between decisions and imperfect information restrict the planner from finding it with certainty. Airlift planning involves best using available time and information to make sound decisions.

The mix and order of objectives for an airlift planner depend upon an operation's environment. As operations are dynamic, reacting to changes in national requirements, airlift objectives can change during planning. Consequently, operations are rarely the same and seldom does actual airlift match that initially planned (Cochard and Yost, 1985:54,55).

Four broad activities comprise airlift planning:

1. investigation,
2. detailed static planning,
3. implementation and dynamic management, and
4. performance monitoring and review (Thyer, 1991; Mitchell, 1991; Peak, 1991a:4 July).

Investigation

Investigation first groups and evaluates resources and requirements. This occurs after operation concepts and expected resource allocations have been defined by higher command as depicted in Figure 4-1. Capability data is gathered on aircraft and airfields, as is characteristics of likely payload. Resource allocations are also examined. These activities seek to gather data for later application in

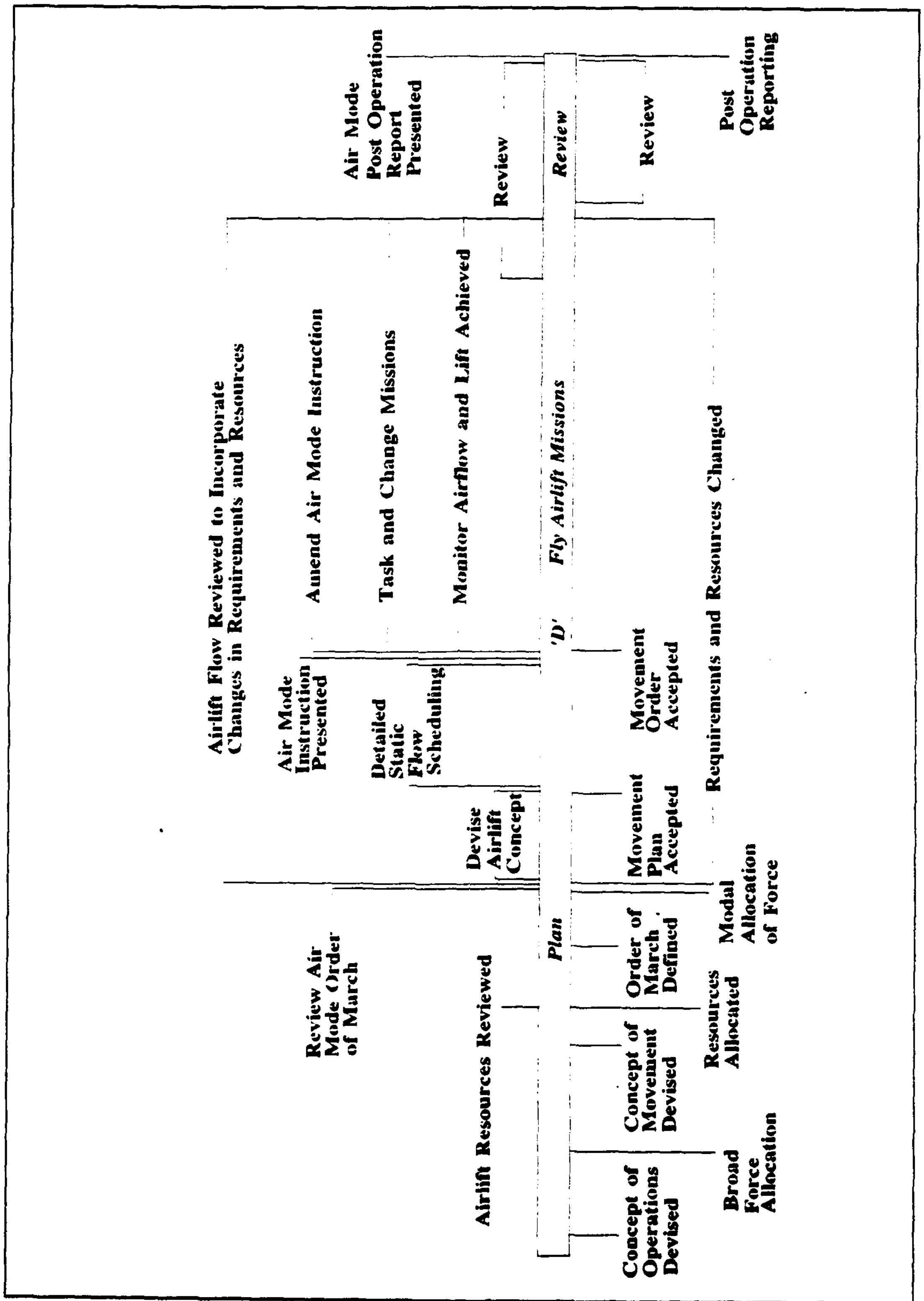

Figure 4-1. Airlift Planning Activities Mapped to Wider Operation Milestones.

detailed planning and to eliminate options that are obviously infeasible because of requirement or resource limitations.

With better definition of requirements and resources, pre-planning can commence. This involves deriving strategies for the application of airlift, determining users' requirements and broadly matching resources to meet their requirements (Thyer, 1991). The likelihood of requirements being met within resource allocations is evaluated. Additionally, aircraft types, airfields and routes which will require close management are identified.

At this infant stage of an operation, the environment is rarely stable and requirements and allocations may not be defined to sufficient detail. Consequently, there is little motivation to plan in great detail and exhaustively test feasibility of ideas (Peak, 1991a:4 July).

Investigation activities aim to derive an airlift concept that is acceptable to the force commander and is based on sound principles of movement management. Force commanders often must compress the time available for concept planning as little other operations planning is possible until a concept of movement is defined. Despite limits on information and time, investigative activities remain vital, providing resource and requirement data for later use and laying a strategic base for subsequent planning activities.

A class of airlift planner exists solely in this phase. Called the "deliberate planner" by the USAF, this type of planner is responsible for assessment of broad capability and development of concept plans (Peterson, 1991). While the traditional planner has operation "womb to tomb" commitments, the deliberate planner is concerned with proofing strategies and concepts and not with later

implementation. He seeks ways to quickly, though accurately, make assessments of airlift capability. For the deliberate planner, investigation results in a statement of maximum and expected flow that is likely from a mix of resources and requirements.

Detailed Static Planning

Upon acceptance by a force commander of an airlift concept, planners, other than the deliberate type, must commence detailed allocation of requirements to aircraft and the scheduling of aircraft flow. Detailed static planning involves moving from a concept of airlift to a detailed plan for application of airlift.

The core product of detailed static planning is a schedule of flights that meets all requirements and does not exceed resource allocations. The term static applies because it is performed after firm allocation of lift resources and requirements, but before the dynamic influence of airlift that is under way.

Payload Allocation to Lift Type

During payload allocation, total aircraft load requirements are calculated by aircraft types, routes and time windows. An aircraft load assessment prepares for later aircraft scheduling activities. It involves aspects of space estimation and effective assignment.

Planners seek ways to quickly deduce total load requirements by applying heuristic methods to convert requirements in loads. As illustrated by Figure 4-2, more time is available compared to earlier planning, though more detail is needed.

Payload allocation should not be confused with individual task loading and pre-planning which occur during the airlift. At that

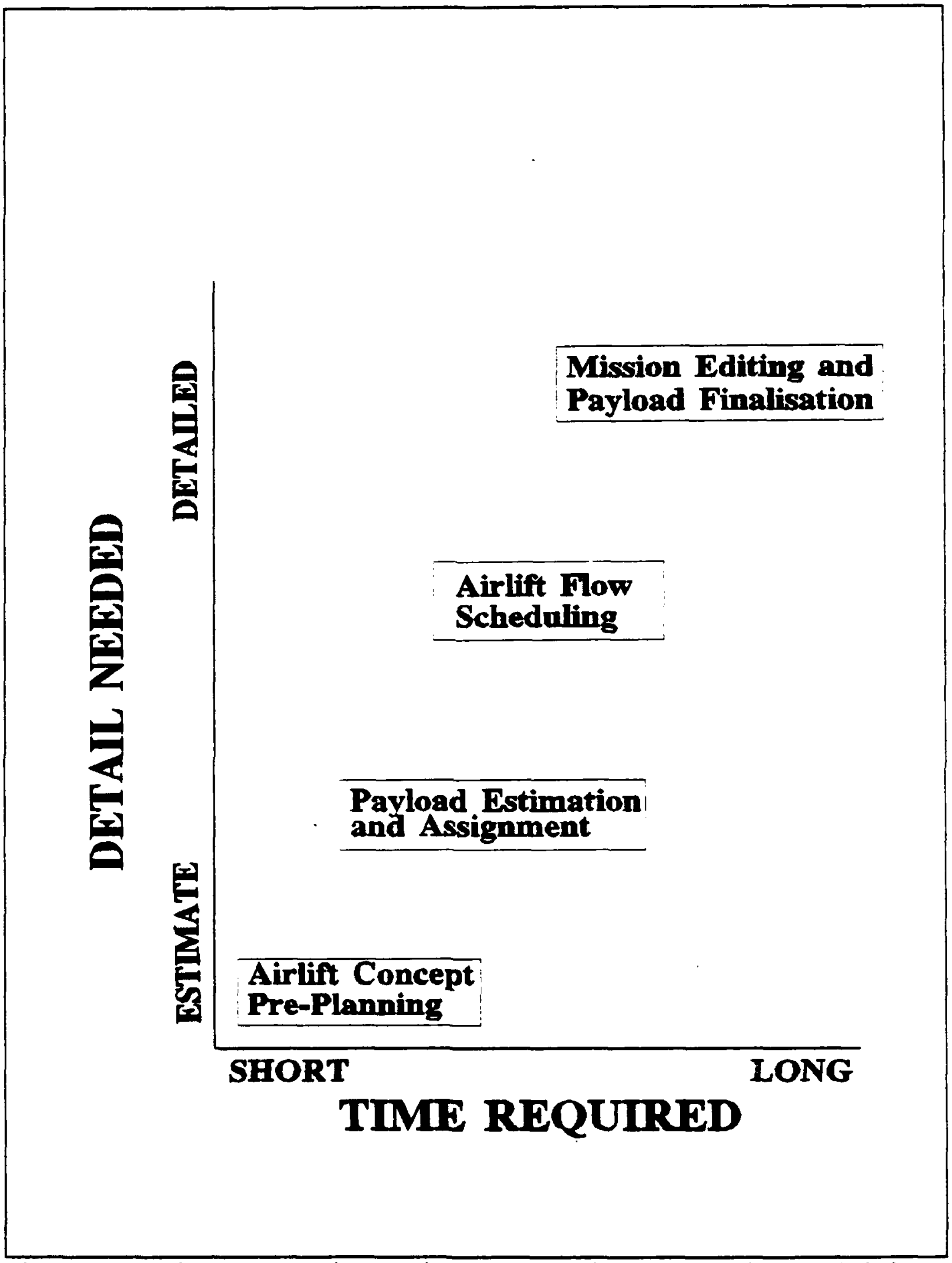

Figure 4-2. Time and Detail Requirements of Airlift Planning Activities.

stage, aircraft are tasked and loads finalised and available for inspection. Detailed loads are planned for each leg of a mission.

Conversely, at the payload allocation stage, only concepts of airlift are available. Loads are ill-defined and not assembled. Time constraints and lack of information limit allocation to numbers of loads and not composition of each load.

Lift requirements can be expressed in different units. For large forces or those that move regularly by air, requirements can already be defined in aircraft loads. Obviously, this approach best suits planning by avoiding load estimation. However, difficulties arise where aircraft of different characteristics are available or the lift customer is not regularly deployed by air.

More commonly, especially for smaller forces, lift requirements are defined by cubic volume, tonnage or both. These measures are easier to derive but cause inaccuracies for planners.

An aircraft has both volume and weight maximums. Because only total volume and weight, and hence average density, are available, estimation of sub-load densities to derive approximate aircraft space is required. Use of different density estimates for classes of cargo improve the accuracy of predictions.

Aircraft of different characteristics are often available to service tasks, though the type of payload may limit choice of aircraft type. If payload can be carried by more than one type of aircraft, some analysis is required to deduce preferred type.

Routing and Scheduling of Airlift

With aircraft loads identified, the next task is to introduce aircraft to fly missions that lift identified loads. Missions must meld

into an effective and efficient flow. The flow should seek to maximise payload carried, relative to payload priority, and yet allow opportunity for rapid change in response to scenario or resource disposition changes. The aim is to devise a flow of aircraft that is balanced and approaches maximum aircraft utilisation and payload carried.

While a deliberate or theoretical planner seeks to gauge the maximum capability of a resource allocation, the operations planner seeks to devise a flow that offers flexibility. Flexibility is usually gained by retaining excess capability within the flow.

Excess capability, or slack in airlift flow, allows quick solution to unexpected problems with least disruption. Yet, this safety slack is a source of inefficiency. If there is excess capability in a flow, then capability of a particular resource allocation has not been maximised.

Output of static planning is highly detailed. Planners must be confident that over-commitment of resources is avoided and crew and airfield restrictions are observed. Mission tasking for each aircraft within the schedule must be provided, as well as specifics of payload and infrastructure requirements.

Implementation and Dynamic Planning

Upon approval of an airlift flow and commencement of operations, missions are tasked and aircraft start to fly. Airlift planning now moves from the static environment to the dynamic.

Many argue that this activity is not part of the planning function. In a survey of ADF personnel, a question targeting whether implementation forms part of the total planning function produced a 50 percent agreement. Yet, all respondents suggested that airlift activities were iterative and dependent.

Certainly, actual flying and loading of aircraft and even tasking of crews are not planning activities. Yet, the iterative nature of airlift activities means that control systems must be able to swing quickly from one phase to another. This is most evident during implementation of airlift.

Every time a significant change is required during the airlift, some revaluation of options and objectives must occur to derive the preferred course of action. Consequently, airlift control moves constantly between implementation and planning during flying activities (Mitchell, 1991).

A major lesson learned by MAC during Operation Desert Storm/Shield was the need to have systems that bridge the gap between planning and viable execution (Peterson, 1991). Compared to exercises, the chaos of real operations restricts time to plan and implement changes to a flow from days to hours, while increasing the scope of likely changes (Babb, 1991:15-16). "The requirements for airlift have almost always been greater than expected at the beginning of the conflict, and the variety of missions performed by airlift increased measurably as the conflict developed" (Cassidy, 1986:124)

The airlift planner has the responsibility of committing airlift in the most effective and efficient way to achieve the force commander's requirements. This responsibility ends when airlift has either achieved or failed to achieve requirements. Therefore, as factors change during implementation of lift, previous planning phases must be revisited to devise reaction.

Planning during implementation involves similar activities to those of the static planning phase. However, changes in the environment

demand different operating approaches. The environment has now moved from the somewhat static pre-commitment phase, to the dynamic phase. Aircraft break down, crews get sick and loading equipment fails. Planning, therefore, adopts more line responsibilities, attacking problems that are developing in the flow.

New requirements are presented and resource allocations change in response to larger scenario developments. The flow must be changed to achieve new priorities. But now the flow is no longer just a plan. Aircraft are flying, crews are committed and payload is on-board.

Any re-routing and scheduling of airlift is governed by a defined start state which is the actual disposition of aircraft, crews, loads, and support facilities. Often there is also a defined after state the flow must return to, so as to meet original priorities.

<u>Review</u>

Airlift culminates with achievement of an objective, within imposed constraints. For large scale airlift, some analysis may be required to determine if objectives are achieved and constraints observed.

Additionally, some feedback mechanism is required to evaluate planning decisions made against outcomes. This is most relevant in airlift exercises which aim to better prepare a force through application, be it actual or notional. Decisions taken by the planner are reviewed for soundness of decision approach and accuracy of data.

Review is not performed exclusively after flying has ceased. Only through measurement and feedback during airlift can it be gauged whether airlift is moving towards achievement of objectives at planned rates and if resource availability is as expected.

Executives demand timely advice of actual performance during implementation. Feedback during implementation, of actual performance versus expected performance, allows airlift to be managed towards changing goals in lieu of being set on a course towards expected outcomes.

Theoretical and Automation Issues

No facet of airlift planning is "too difficult" to automate. However, the wide influence of an operation's environment on airlift planning has frustrated attempts to apply automated systems to airlift.

Fully automated systems, such as expert systems, depend on a knowledge base of rules (Cook and Russell, 1989:720). Their construction usually requires rigorous definition of factors, options and benefits. The effort to collect and define data concerning the vast array of potential factors that affect complex planning environments is large. Additionally, constraints may be too nebulous and hard to define (Bodin et al., 1983:182). By the time data on all possible factors has been collected and constraints defined, the benefits of speed and accuracy normally associated with automation are seriously undermined (Bodin et al., 1983:182).

User acceptance of computer generated solutions is most impeded by a feeling of the user's loss of control over the underlying physical system (Bodin et al., 1983:182). By including man-machine interaction in computer systems, better solutions are being obtained and, more importantly, wider user acceptance is gained (Cochard and Yost, 1985:56-57; Bodin et al., 1983:182).

Interactive systems have great potential application to airlift planning. Users can apply intuition or knowledge to break the total airlift problem into sub-problems. Sub-problems can then defined rigorously and solution approaches directed. With problems bounded and solution approaches defined, quick and accurate solutions are available through automation (Cochard and Yost, 1985:57).

Estimation of Loads

The loading of aircraft is well researched and is a form of the load optimisation, knapsack and greedy problems (Horowitz and Sahni, 1990:51-64). Noteworthy works of theory addressing aircraft loading include those of Eilon and Christofides (Eilon and Christofides, 1971) and Huebner (Huebner, 1982). Unfortunately, much of the literature on the load problem is too theoretical or does not treat many real-life constraints (Cochard and Yost, 1985:56).

Automated systems for load planning have difficulties in reconciling the flexibility of movement priorities into formulations. Reasonable solutions are hard to generate given the lack of information available at early stages of planning. Most successful systems rely upon interactive systems to overcome these difficulties (Cochard and Yost, 1985:56).

Assignment of Loads to Type

Assignment of payload to aircraft type is often done manually based on intuition and experience. Automated assignment is based on a heuristic of using the vehicle with the largest carrying capacity, provided an economical amount of carrying capacity is used. This heuristic assumes that economies of scale ensure larger vehicles provide cheaper per ton delivery costs (Bodin et al., 1983:107-109).

Load assignment to aircraft type is a generalisation of the operations research transportation problem. Mathematically, this is not a hard problem giving it useful practical potential, as discussed later in this chapter. Automated methods to optimise assignment to vehicles have undergone considerable research in the last thirty years. Several techniques, including Charnes and Cooper's stepping-stone method and Dantzig's modified distribution method, provide specialised solution methods (Cook and Russell, 1989:202).

Scheduling of Aircraft

The scheduling of aircraft is also well researched, falling into the routing and scheduling component of operations research. Routing specifies the sequence of airfields that flights must visit, while the schedule identifies the times at which the activities at these locations must be carried out. The problem's structure allows application of set, graph and network problem definition and solution approaches (Bodin et al., 1983:77-78; Cook and Russell, 1989:219; Horowitz and Sahni, 1990:336,364-372).

Routing and scheduling problems are generalisations of the classic travelling salesman problem, which Karp has proven to be mathematically hard (Bodin et al., 1983:82). The airlift generalisation of the routing and scheduling problem is called the pickup and delivery problem with time windows. It is characterised by task precedence and time window constraints (Solomon and Desrosiers, 1988:7-8).

Task precedence relationships force the pickup activity for a task to precede the delivery activity and pickup and delivery to be by the same aircraft. This last constraint simply means that loads cannot change aircraft in flight or the problem cannot be divided into separate

pickup and delivery problems with share depots. Airlift scheduling can also involve sub-component problems, such as crewing (Bodin et al., 1983:117-147; Sklar, 1990).

Routing and scheduling solution methods often divide a problem into its spatial and temporal components. They then derive feasible solutions to one component and apply them to the second. The aim is to divide the problem into smaller more tractable pieces.

Even without time constraints, the routing of aircraft is a hard problem. Yet, at least a network that includes all tasks can be constructed a priori. This means that routes are predefined and always available. The difficulty lies in finding the optimal traversal of the network.

With time windows, "the complete set of tasks that can feasibly follow a given task cannot, in general, be specified beforehand since the exact time of service for a given service cannot be specified in advance" (Bodin et al., 1983:149). This means that in contrast to a pure routing or spatial problem where a network remains static during its transit, time and space considerations may cause a network to change during its transit. For example, the route between two nodes may only exist between 9.00 am and 10.00 am.

Not surprisingly, the routing and scheduling problem with time windows has been proven to be at least as hard as the travelling salesman problem (Bodin et al., 1983:149). In fact, even finding a feasible solution to the problem has been proven hard (Solomon and Desrosiers, 1988:4).

Implications of Hard Problems

There are implications of a mathematically hard problem. Figure 4-3 charts problem complexity against computational time, though space is equally applicable. Functions with less than exponential and exponential relations between complexity and time are plotted.

As expected, time to solve a problem increases with problem complexity for all functions. Yet, for functions with a less than exponential relationship between complexity and time, the rate of increase is bounded and remains somewhat reasonable. Mathematically, these functions represent methods that are not hard. Generally, a solution can be generated for complex problems, though the time to generate may become long. Importantly, there is no rapid degradation in computational time for each step up in complexity (Horowitz and Sahni, 1990:37).

For example, if the relationship between complexity and solution time is linear, a problem twice as complex requires twice as much time to generate a solution. This is true whether the original complexity is $n=2$ or $n=10$.

The exponential plot (2^n) of complexity against solution time shows time to solve a problem also increases with complexity. Here, if the original problem has complexity $n=2$, then a problem with twice the complexity ($n=4$) will require quadruple the solution time of the original ($2^2=4$ versus $2^4=16$). But if the original has complexity of $n=10$, then twice as complex means $n=20$ and the solution time is multiplied by over a thousand ($2^{10}=1\ 024$ versus $2^{20}=1\ 048\ 576$).

For exponential functions the rate of increase is steep and quickly approaches, though never reaches, infinity. Increases in

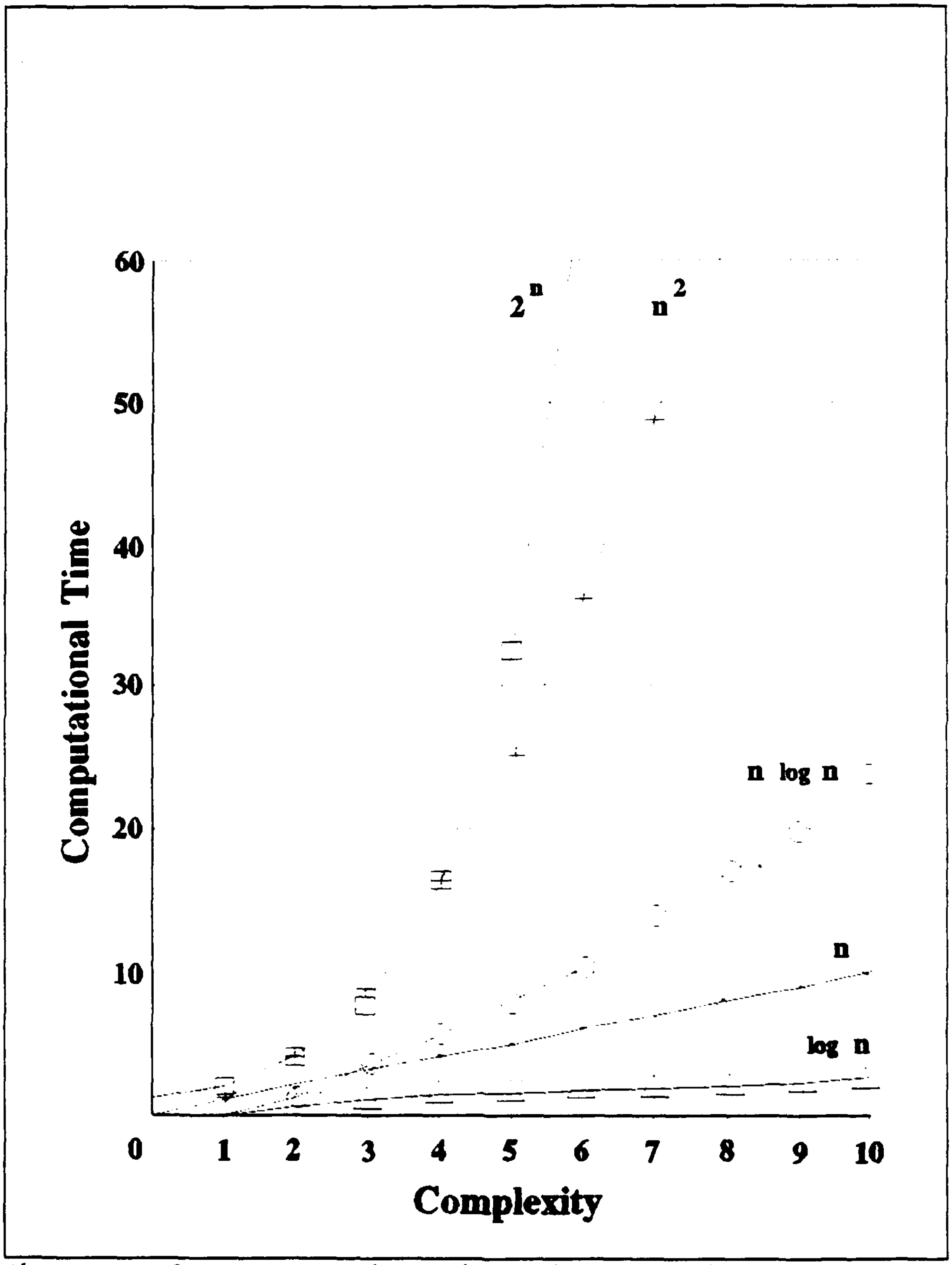

Figure 4-3. Plot of Computational Time Against Complexity.

complexity beyond the lowest levels will result in very large increases in solution time. A level of complexity is quickly reached where an optimal solution will only be generated in time approaching infinity. An exponential lower bound characterises a hard or intractable problem. Methods with high polynomial degree or exponential relationships between complexity and time are of limited practical utility (Horowitz and Sahni, 1990:37-38).

Complexity is a general term applied to problem definition. For routing and scheduling problems, complexity generally increases as the number of airfields, aircraft or loads increase or time windows reduce (i.e. become tighter). Most aircraft flow problems for military operations are complex. Given the intrinsic difficulty of the problem class, heuristic methods have become the focus of practical investigation (Solomon and Desrosiers, 1988:6).

Heuristic Approaches

The routing and scheduling problem with time windows involving either pickup/drop only or full vehicle loads has been solved by Desrosiers, et al. (Solanki and Busch, 1991:1). However, a computationally feasible technique for real-world problem has not been found (Hilliard et al., 1991:13). Instead, heuristic methods have been applied.

Heuristics are "approximate methods to obtain near-optimal solutions in lieu of seeking optimal solutions" (Bodin et al., 1983:76). They are effective if they provide solutions consistently close to the optimal solution while improving time to derive a solution.

Because heuristic methods consider a sub-set of possible solutions they are prone to restricting their search to areas where

feasibility, let alone optimising, is not possible. Consequently, heuristics tend to be tailored to specific problem scenarios. Selection of a heuristic method, given a problem environment, is seen as a possible application for an expert system (Solomon and Desrosiers, 1988:9-10).

Different heuristic approaches have been applied to routing and scheduling problems. Some rely on simplifying route choice to bound solution space, such as use of sequential or clustering approaches (Solomon and Desrosiers, 1988:9). Others attack sub-components of the total problem that can be solved optimally and rely on sub-problem improvements to make overall solutions attractive. Tour improvement is another approach, which takes an initial feasible solution and attempts to maintain feasibility, while moving towards better solutions (Christofides, 1985:443-447).

To overcome limitations in heuristic performance caused by the scenario, researchers are proposing solution approaches that apply more than one heuristic to a problem and then choose the best result (Fisher and Jackumar, 1981; Lawler et al., 1985:176-177).

Soft Constraints

Difficulties with complexity and definition of problem constraints abound in practical aircraft routing and scheduling applications. Allied to these difficulties is the presence of hard and soft constraints (Solomon and Desrosiers, 1988:1-2). Being based on rigorous definition, mathematical approaches to airlift flow problems best suit applications where all constraints are hard, meaning firm or discrete. Examples of hard constraints include a 15 hour crew day, a maximum of

five aircraft or a movement window defined to the day suit solution approaches.

Yet, many constraints are soft or flexible in nature. Crew days can often be extended if sufficient incentive exists. Movement windows are often not discrete. Though it may appear that firm boundaries exist between acceptable and unacceptable delivery periods, a sliding cost of late or early delivery is usually the case. A force commander may accept a late delivery if related advantages gained by such a decision are sufficient.

Solution methods attempt to recognise soft constraints by either using many discrete constraints to model a continuous constraint or through relaxation techniques. Relaxation techniques incorporate continuous constraints by recognising them as costs in the objective function (Solomon and Desrosiers, 1988:1). The objective function is "the equation used to measure the effectiveness of a proposed solution" (Cook and Russell, 1989:12). By removing constraints, relaxation techniques simplify the generation of feasible solutions. They then incorporate opportunity cost coefficients in the objective function to artificially apply the requirements of the constraint.

For example, a soft time window constraint for movement may exist. Not applying this constraint allows many "feasible" solutions to be generated. However, where movement occurs outside the window, a penalty is applied by multiplying a constant by the time that falls outside the window. This provides recognition of the continuous window constraint and effectively eliminates options that excessively abuse the window constraint.

Dynamic Airflow Scheduling

Static and dynamic aircraft flow systems share many similarities. However, the speed of airlift shortens reaction and decision cycle time, thus suggesting the use of heuristic and rapid methods (Bodin et al., 1983:177).

In dynamic scheduling, objectives change from finding the best solution to finding the best way to move from the present state to some future state defined in the plan. Systems must be able to integrate the present state and understand the desired future state. To do this there must be definition of what can and cannot be changed and the cost of change.

Academic study of dynamic routing in the dial-a-ride taxi applications have considered costs to date as sunk and eliminate them from the problem (Bodin et al., 1983:179). This converts the dynamic problem to a static consideration with dispersed vehicles and customers. Civil airline systems apply similar least cost and disruption heuristics in reaction to schedule difficulties (Bodin et al., 1983:156).

Measurement of Airlift Planning Performance (Resources and Financial Programs Division-RFPD, 1990:Chapter 6)

The development of performance indicators facilitates efficient and effective management by identifying areas that might require corrective action or refinement, often because of changing external conditions, or requiring further in-depth investigation (RFPD, 1990:6-1). In so doing, it provides for ongoing scrutiny of approach and achievement.

Information and feedback on performance that has been collected on a regular and systematic basis can be useful and valuable to airlift planners for the following purposes:

1. Planning. It facilitates the choice of strategies to achieve goals and identifies priorities and suggests changes in approach to airlift planning.

2. Budgeting. Feedback helps justify bids for resources to executive management and force commanders and allows development of targets, milestones and standards as part of the planning system.

3. Implementation and monitoring. It monitors progress against resource constraints, lift requirements and overall objectives and guides appropriate corrective action in order to keep an airlift plan "on track" for maximum achievement of results.

4. Evaluation. Performance review allows assessment of achievement of particular airlift planning objectives, demonstrates the contribution of airlift decisions to higher operation objectives and provides information from which policy variations can be developed.

Seven indicator types are typically applied to measuring airlift planning:

1. Output, which is the quantity of airlift service provided.
2. Responsiveness, being the elapsed time to execute airlift.
3. Productivity which is the workload per airlift resource.
4. Efficiency or cost per unit of performance.
5. Effectiveness which is the extent to which airlift reaches its objectives. Also called outcome, effectiveness measures operational and surge capability of airlift resources.
6. Cost-effectiveness which seeks the unit cost of effectiveness.

7. Qualitative which provide judgemental assessments of product quality concepts such as service standards.

ADF Airlift Planning (Peak, 1991a:5 July;Newcombe, 1991:28 July; Small, 1991: 28 July)

Both aircraft tasking and payload management for ADF operations is performed by ALG, the transportation component of RAAF's Air Command. For small scale and short term operations, ALG provides all planning staff, while for larger operations, staff are supplemented by RAAF full time and reserve members. Different planning procedures and staff are used for operations and normal peacetime airlift.

External agencies that interface with ALG include civil operators of aircraft and airport facilities, higher headquarters and movement control agencies (Peak, 1990a:6 March). Movement control agencies act as intermediaries between the users of airlift and ALG (Department of Defence, 1988b:12).

In its airlift planning role, components of ALG become external customers to the airlift planning process. These components include flying and intermediate maintenance squadrons and air terminal agencies. Air terminal agencies are located at RAAF and civil airfields and provide loading and other turnaround tasks for transiting ALG aircraft.

Separate staff are responsible for aircraft tasking and payload management. They are co-located, but maintain separate files concerning an operation and tasking folders for each mission. Though they share data concerning allocation, scenario and tasking, each maintains relevant documents on their own files (Small, 1991). This leads to duplication but cannot be avoided as ready access to operation or mission information is required by each (Newcombe, 1991:28 July).

Each function maintains a general operation file. This file is the repository for all correspondence of a non-specific nature concerning the operation. Subordinate files maintain specialised aspects, including planning and working data. Publications that provide resource capability or requirements characteristics are kept by any staff that require the information.

For historical record, all files are maintained for a reasonable period. Tasking folders generated by each function are also stored, although each component stores its files and folders separately (Newcombe, 1991:28 July).

Eight discrete functions are performed. Firstly, operation scenario, requirements and allocations are investigated, mostly by the aircraft tasking section. Where airlift is proposed within the next two months, current committed tasking over the period is determined from flight folders and a board maintaining proposed tasking. If expected airlift falls outside the two month period, little action is taken unless a clash with another commitment is expected (Newcombe, 1991:28 July).

When firm requirements data become available, load estimation, flow scheduling and tasking can commence. For larger operations, the section responsible for payload management estimates load requirements and designs a flow that meets requirements effectively.

Different approaches are used for smaller operations. For these, either section may perform lift requirement and flow design. The reduced operation size allows more detailed analysis of load estimation and aircraft flow. Additionally, outside organisations sometimes seek responsibility for airlift planning in support of their exercises.

Aircraft routing and flow control is performed manually. No formal advice on methods of routing and scheduling exist, so techniques applied vary between planners (Newcombe, 1991:28 July). On small applications, an exhaustive search of options the planner considers reasonable can be performed. For repetitive exercises, old flows become the basis for proposed flows. For larger operations, intuitive and heuristic methods are applied.

After review by the tasking section, either section may staff the proposed flow to the operation's mounting authority for concurrence. An air mode instruction is generated based on the approved flow though its format varies with planner preference. This instruction is passed to movement control authorities for coordination with units.

Committed airlift for the operation is updated to the proposed tasking board. Mission tasking is generated to meet the flow by the aircraft tasking section. Hard copies of each resulting aircraft tasking are directed to flying and maintenance squadrons and transited terminals. Separate folders for each mission are maintained by the aircraft tasking and payload management sections and each has a monthly flights board.

For all operations, load changes must be managed and flying squadrons and terminal units advised of actual payload details at least the day before flights occur. Yet, payload management is also performed in different ways, depending on the size of the operation and preferences of staff coordinating the operation. On larger operations, some planners maintain payload assignment within flight folders while others use a master air mode instruction to record assignment. Computer maintenance of assignment has been used on some recent operations.

For smaller operations, assignment is easier to manage. Consequently, planners often incorporate load assignment into mission tasking documents or apply other approaches.

Inevitably, changes to planned airlift occur. Prior to flights commencing, changes are managed by the planner responsible for original actions. For example, the payload section would be responsible for all changes if they had planned the airlift. Changes to flight times and routes are managed by the tasking section, as are aircraft rescues.

Information concerning actual performance both during and after airlift is based on "a negative feedback process in the form of the reporting by exception" (Mitchell, 1991) by flying squadrons and terminal units. Performance is assumed to be as planned in the absence of feedback (Mitchell, 1991).

Each day, flight folders for completed flights are removed and status boards incremented. Flying squadrons advise actual hours flown for each operation on a monthly or an as requested basis. Post-operation reporting is usually performed, though hours flown and lift met are not analysed against that planned. Most reporting addresses negative feedback to mounting authority, customer and other agencies. Besides digital assessment of achievement of requirement, no assessment of performance or decision quality occurs.

Automation

ADF airlift planning is performed manually. A management commissioned report in 1981 found that the manual approach to airlift planning suffered problems with communications and information management and availability. A computer based system was proposed to improve efficiency in the use of manpower, eliminate most opportunities

for lost information and improve coordination and control of operations. However, most recommendations of this report were not implemented.

Since an exercise in 1989, airlift plans have been able to be stored electronically. However, decision making continues without computer support and data is often stored manually.

Frequency and Size of ADF Airlift Operations

Appendix D provides statistics of frequency and size of ADF airlift operations. Results are based on actual data from the last four years and opinions of ADF staff.

Measurement of Planning Performance

Questions in a survey of ADF airlift planning personnel targeted those factors that influenced airlift planning approach and the metrics that could measure planning performance. Appendix C provides those results.

Eighteen potential factors were identified to respondents, who were encouraged to add others. Factors considered were:

1. overall effectiveness of airlift in meeting the aims of the customer,
2. productivity or maximising payload lifted,
3. economy or committing resources in the most effective way,
4. efficiency or the highest ratio of productivity to costs,
5. simplicity of plan and tasking,
6. training value to the airlift system,
7. fluidity or smoothness of lift,
8. cohesion or unity of lift,
9. flexibility or ability to absorb later changes,
10. certainty of meeting lift requirements,

11. accountability for decisions made,
12. control or ability to quickly influence the flow,
13. sensitivity to alternative strategies,
14. format that allows quick development,
15. speed of plan development and distribution,
16. security of airlift resources,
17. security of payload, and
18. concentration of airlift effort for maximum efficiency.

Generally, planners identified overall effectiveness as the principal factor of airlift planning. Though few could suggest good measures of overall effectiveness, most thought it could be measured beforehand.

Pressed for more defined factors, most planners suggested that more than one factor influenced planning. Ordering of these factors was considered either insignificant or dependent upon operation scenario and all suggested different ordering. Interestingly, usually conflicting factors of economy and flexibility ranked after overall effectiveness as principal factors.

Deficiencies in the Present System

Deficiencies in ADF airlift planning occur in six areas:

1. lack of data control, including risk of loss, lack of integrity, restricted access, inflexibility of format and inaccuracy;
2. repetition of structured tasks;
3. lack of consistency in planning approach;
4. long learning curve for new planners;
5. distribution delays and problems; and
6. lack of feedback.

Data Control

Much data is maintained in longhand form. It is held loosely by actioning staff or placed on one of four types of file. Given the amount of paper generated in operations management, it is not surprising that some data is lost or misplaced. In times of exercise or aid to the community, this may lead to political embarrassment. In war, loss of tasking or requirements data may lead to death (Management Advisory Services Branch-MASB, 1981:12).

Data often needs to be accessed by more than one person. This is achieved either by speedy passing of files containing original copies of data or by maintenance of numerous copies of documents. Passing of files introduces problems with lost files and delays in advise of changes to interested parties. Many distributed copies of the same document poses problems with update and currency due to difficulties in finding and accessing all copies of documents.

Longhand format is inflexible as it does not support free formating of data (MASB, 1981:8). This increases the time to extract information value from data introducing overhead in presentation of data by summary, combination and linking. Inaccuracies also occur through errors of transposition and transcription when data is ported from one document to another (Small, 1991; MASB, 1981:7-10).

Inflexibility of format has greatest impact on sharing of information between levels of management and movement of information between planning activities. No way exists to quickly transpose information from a strategic or conceptual level state to a state suitable for continued detailed planning.

Additionally, there is no ready way to summarise airlift state. This inhibits movement from detailed planning back to strategic planning in response to major changes in scenario. It also delays and frustrates sharing of information between levels of management, often leading to inconsistencies or absence of timely reporting.

In all, maintaining data in longhand form increases time to locate and present information while reducing its accuracy. Decision cycle time is extended and decisions are less likely to be timely. Where strict time limits to make decisions are imposed, they are based on less information, even though source data is available (MASB, 1981:7).

Repetitive Structured Tasks

The absence of automation means that all tasks are performed manually. As airlift planning involves many repetitive and highly structured tasks, human resources are used inefficiently (HQMAC, 1987:6-1). Skilled staff become involved in unskilled tasks and must sacrifice time available for decision making to perform these structured tasks (MASB, 1981:18). For example, aircraft tasking requires check digit calculations on timings to reduce transcription error. For a large exercise, check digits may be manually calculated up to 1 000 times. This is a simple task that consumes time. Further, an inaccurate calculation causes return of tasking advice for correction, increasing the decision advice turnaround. Similar situations abound with data such as unit names, mission numbers and connecting movement detail.

Given that time is critical, especially when airlift is under way, time available for decision making should not be reduced by structured but necessary tasks.

Lack of Consistency in Planning Approach

Clearly, no formal system for planning airlift for operations exists. Different approaches are used based on operation size, type of customer, processing section and staff involved. All approaches differ from those used for normal peacetime planning.

This causes confusion when planning responsibility moves between staff and introduces unnecessary delays in processing. Delays and misunderstanding are extreme when planning responsibility must be handed from one planner to another at short notice. Additionally, external agencies are not presented with a consistent approach from ALG, causing delays and misunderstandings.

Long Learning Curve for New Planners

Given that no formal system for airlift planning exists that new planners can learn and the absence of critical reviews of previous planning decisions and approaches, each new planner experiences a long learning curve before becoming capable of planning effectively. The need to learn structured tasks before moving to unstructured tasks further extends the learning period.

Further, as the planner is largely on his own during this learning phase, new approaches to planning are likely to be found by each new planner.

Distribution Delays and Problems

During actual airlift, changes to the air mode instruction must be quickly generated and distributed if it is to be effective. Unfortunately, transmission time is usually measured in days, while their impact is often in hours. Late arrival of updates not only make

them of little use but can lead to confusion and frustration for external agencies.

As different approaches are used in formatting and distributing air mode instructions, there is no standardisation concerning receipt confirmation and copy or issue number management. External agencies are unsure of instruction accuracy and are confused when different versions of the air mode instruction conflict. Additionally, no secure means exists for delivering changes in time and in a form immediately useful to external agencies.

Lack of Feedback

With exception of negative feedback, no reporting of actual performance occurs. Planners must assume actual airlift exactly matches that planned, even though this is not usually the case.

Firstly, this impacts on the accuracy and quality of advice to all levels of management and ultimately the force commander. Secondly, planning data used by planners becomes dated and inaccurate as better actual lift data becomes available. This is most relevant where planners must redeploy a force based on planned deployment data, when actual deployment data is available but not accessible. Lastly, there is no analysis of planned versus actual performance to gauge where processing can be improved or better decisions taken.

United States Military Airlift Planning

MAC is a major USAF command and a component of the United States Transportation Command (USTRANSCOM). It is the principal agency for providing airlift for the United States Military Forces (Hilliard et al., 1991:2) and is the largest provider of airlift in the world having,

in 1986, "an active duty primary aircraft authorisation of 70 C5s, 242 C141s and 230 C130s" (HQMAC, 1987:4-1). In addition, MAC schedules use of Strategic Air Command's KC10s and contracts an average of ten commercial carriers each day to provide cargo and passenger transport (HQMAC, 1987:4-1; Hilliard et al., 1991:2).

While many of the operations that MAC supports are of the same scale as ADF operations, airlift management is designed for large scale airlift (Fairlie, 1991). Payload management is separated from aircraft flow management and mission tasking. Heavy use of automation is made in both areas.

Within payload planning and management, smaller systems are used by units and commands to manage loading of aircraft. Though these systems are designed for use with actual loading, they are applied in pre-planning stages of airlift. Principal among these systems is the Computer Aided Load Manifesting system (CALM), though others such as Cargo Movements Operations System (CMOS), Contingency Operation Mobility Planning System (COMPES) and Automated Mobility Schedule of Events (AMSOE) are available.

Currently, a new system is being introduced to assist aircraft flow scheduling and management. The system also contains limited load assessment capabilities. Called the Airlift Deployment Analysis System (ADANS), the system was first used in real life operations during Operations Desert Shield and Storm, during 1990 and 1991.

Measurement

MAC uses a financial tool to manage its airlift resource and to introduce cost visibility to the air movement of passengers and cargo (Trott, 1991). The Airlift Service Industrial Fund (ASIF) is a seeded

funding pool from which MAC must finance airlift operations. In turn, MAC charges its users for airlift. Charges are based on actual airlift costs, for civil and some military flights, or an average cost per flying hour by type that is computed annually.

As a measure, dollar cost is easily understood and allows commanders to rate airlift against other means of transport (Trott, 1991). As airlift impacts on each user's budget (at Major Command Level) in a direct and obvious way, users have greater incentive to consider efficiency in requirement definition and scheduling decisions (Trott, 1991; Fairlie, 1991). Responsibility to efficiently apply airlift becomes a shared responsibility between the paying customer and the airlift provider (Trott, 1991). As users can be charged based on actual usage, they are further encouraged to consider efficiency during implementation stages of an operation (Trott, 1991).

To planners, charging in dollar terms allows MAC flexibility in choice of aircraft type and mission profile to meet tasking (Tueurkauf, 1991). Also, it shifts responsibility to judge when efficiency must be sacrificed for effectiveness to the user, who is expected to have a better appreciation of the larger needs and factors of the operation (Trott, 1991; Tueurkauf, 1991).

However, to apply a market approach to efficiently manage the scarce resource of airlift, basic micro-economic principles must be observed. Users must appreciate scarcity of the resource and have limited ability to satisfy their airlift needs. Consequently, dollar cost has been ineffective where users have not been tied to budgets (Peterson, 1991).

The ADF has long been criticised for its financial management and reporting and the depth of its accountability for its performance (Resources and Financial Programs Division, 1990:1-1). In line with demands that managers be able to demonstrate the efficiency and effectiveness of their organisations, the ADF has embarked upon a Financial Management Improvement Program (FMIP). Part of FMIP is a move towards Project Management and Budgeting. PMB is expected to provide the ADF with improved cost metrics for airlift measurement (Peak, 1991a:3 July).

CALM (Cochard and Yost, 1985)

The Deployable Mobility Execution System (DAMES), later called CALM, "was developed for the USAF to improve aircraft utilisation and responsiveness in airlift operations" (Cochard and Yost, 1985:53). The system runs on a small, off-the-shelf microcomputer and uses interactive graphics to generate loads for aircraft. Programmed in C, the system is aimed at inexperienced load planners, though superior performance is possible with experience.

Design objectives for the system were:

1. Speed. Manual load planning took too much time. Load planners were too bogged down with arithmetic to optimise the amount of cargo moved.

2. Accuracy. The system had to catch load planning errors, often missed in manual planning, and provide ways to correct them.

3. Flexibility. The system had to incorporate published load planning rules. However, user override was required to allow for real-life conditions and allow for more complex plans.

4. Ease of Use. The system had to be easy to use, produce output that could be trusted and be straightforward to learn.

5. Deployability. The hardware had to be capable of operating in field conditions and without access to communications networks.

6. User Interaction. Full automation of load planning was to be avoided to reduce user dependence on the system.

7. Efficiency. The system had to improve utilisation of the aircraft.

The system comprises three basic functions: a file system, a load plan manager, and a load planning facility. The file system allows definition of requirement characteristics while the load plan manager maintains completed load plans that have been generated by the load planning facility.

The user decides what will be assigned to each load, avoiding problems with computer recognition of priorities. The system then uses a modified one-dimensional cutting stock algorithm to derive a load plan.

Cargo is sorted form largest to smallest. Then, resembling a knapsack approach, largest items are loaded first, proceeding until the cargo compartment is filled or restrictions on weight are reached. The system does not attempt to automatically rearrange cargo to achieve superior solutions or balance. Instead, the user controls sensitivity testing to deduce the best load combination.

Tested during the Grenada rescue operation in October 1983, the system saved over US$2.5 million in flying hour costs by increasing utilisation by ten percent and reducing load planning man-hours by 90 percent.

Unfortunately, the system assumes perfect knowledge of requirements and has limited application in load estimation. Additionally, the ADF's size and doctrine limits CALM's applicability to the ADF (Peak, 1990:12 November; Newcombe, 1991:27 April).

ADANS (Davis, C., 1991; Peterson, 1991)

ADANS is an automated system that will provide MAC with planning, scheduling and analysis tools for peacetime and contingency airlift operations. It consists of a relational database management system (RDBMS); a modelling sub-system containing planning, scheduling and analysis algorithms, and a communications sub-system (HQMAC, 1987:1-1).

ADANS systems are located in HQMAC and the two Numbered Air Forces and are soon to be located in the two Airlift Divisions. It is connected by secure means to the Worldwide Military Command and Control System (WWMCCS), Joint Deployment System and the Joint Operations System (JOPS). Its is also connected to the Global Decision Support System (GDSS) and the Transport Coordinators Automated Information for Movements System (TC AIMS) (HQMAC, 1987:1-1,1-2).

"ADANS is being developed in three increments to reduce risk and to provide an initial operating capability as quickly as possible" (HQMAC, 1987:1-1). Development was planned to occur between 1987 and 1993. However, in August 1990, development took an unexpected turn.

Desert Shield/Storm

Three days into planning of airlift for Operation Desert Storm/Shield, a large scale contingency deployment to the Middle East, the existing computer system, FLOGEN III, failed because of serious shortcomings in capability and user interaction (Peterson, 1991).

Desperate for some form of computer assistance, MAC requested ADANS development be accelerated. Airlift director, General Cole, believed that automated scheduling was vital to the airlift's success (Hilliard et al., 1991:3). In the meantime, MAC continued planning manually (Davis, C., 1991).

Within one month, ADANS testing had completed and the system became MAC's exclusive airlift scheduling system (Hilliard et al., 1991:4). "By 1 May 1991, ADANS had been used to schedule more than 18 500 airlift missions. These missions moved more than 675 000 passengers and 600 000 tons of cargo" (Davis, C., 1991).

Though ADANS provided sophisticated modelling systems, planners ranked a flexible and fast mission editor as the most important component of the system (Davis, C., 1991; Peterson, 1991). While merit was seen in scheduling and proofing systems, greatest time pressure was placed upon planners by the need to quickly change the flow due to shifts in the environment (Peterson, 1991).

Because ADANS was used by planners in both the flow generation and implementation activities, most benefit from the system was derived from its ability to assist in the making of changes to tasking and advising all agencies of these changes. Additionally, the electronic receipt and validation of new requirements was identified as a major improvement (Davis, C., 1991).

The cost of ADANS development during Desert Shield/Storm was approximately US$2 million. This brought total development cost of ADANS to about US$17 million. In comparison, the cost of Desert Storm/Shield airlift was US$3.4 billion, the most intensive airlift to

date (Davis, C., 1991). Each one percent of increased efficiency would have resulted in US$30 million in savings (Davis, C., 1991).

System Functions (Hilliard et al., 1991:7-12; Davis, 1991)

ADANS has peacetime and operational sub-systems. The operational component of the system offers support for all aspects of airlift planning.

Database Establishment

For each operation, ADANS establishes a database organised around airfields, aircraft and missions. Upon establishment, global data concerning airfields and aircraft is copied into the operation's database. Additionally, planners can specify routing and communications requirements and security restrictions.

Processing Requirements

ADANS first checks movements requirement information passed electronically from USTRANSCOM for errors and missing data. If information is found to be within acceptable limits, it is presented to a requirements cell who solicits additional information from the customer.

Where the requirement can be met through commercial airlift, civil carrier interest is called. Civil schedules are proposed to MAC by commercial carriers and ADANS maintains records of civil itineries to ensure overall efficiency throughout the airlift system.

Airlift Resource Availability and Characteristics

Once movement requirements for military lift have been processed, scheduling can begin. Planners first specify aircraft resources by number and type of aircraft available per day. Planners can specify the minimum load that can justify a mission, type of cargo that can be

carried, amount of time required to load and unload an aircraft and maintenance requirements.

Airfield characteristics are modelled by three factors: the number of active aircraft that can be on ground at one time, the maximum number of tons that can be processed through the airfield in one day and the maximum number of passengers that can be processed in one day. Operating hours and minimum separation times are also recorded.

Concept of Operations

In addition to defining the physical limitations on scheduling, planners develop a concept of operations that defines how they want to organise the use of resources. Resource constraints and concept of operations are defined by flow planners using a set of text-based forms and geographic editing tools.

Permitted airfield activities, such as on-load, off-load, refuel, enroute and recovery stop or crew change are specified, and a network of flight legs and sub-networks for specific pairs of airfields are defined. Permission can be specified by aircraft type, configuration or aircraft operating wing.

To manage the airflow at congested enroute airfields and off-loads, planners define a set of prescribed daily departure and arrival slot items. When flow is more relaxed, separation times and parking availability determine frequency of landings and departures.

Creating Mission Schedules

The core schedule generation tool for ADANS is a dynamic programming-based scheduling algorithm. The algorithm receives its data from the ADANS database and returns scheduled missions to the database. Constraints do not need to be modelled in any mathematical form; they

are expressed as resource constraints and permissions, which also allows newly generated missions to be integrated with all currently scheduled missions.

A mission editor allows planners to remain in complete control of the schedule by providing checks and audits as necessary. Automatically and manually generated missions can be added, deleted and modified, as well as copied to create a series of similar missions offset by a prescribed time phase. Additionally, mission feasibility can be checked in terms of crew duty restrictions, weight limitations, ground time requirements and concept of operations.

Analysing Schedules

ADANS provides analysis of a schedule from three perspectives: requirements, aircraft and airfields. With each component able to be viewed in summary form, planners can examine requirements not yet scheduled, flying hours scheduled by aircraft type and planned peak loads at airfields. Text is supplemented by graphical displays that show requirements transported, resources committed and aircraft activities.

Communicating with MAC's Command and Control System

After a mission has been scheduled, a copy is electronically sent to MAC's command and control system. The command and control system provides a worldwide network to follow and manage each aircraft through its mission.

Applicability to ADF

A system such as ADANS has much to offer ADF airlift planning. It offers insight into successful design and development methods for

computer based operational airlift management support systems and provides real-life testing of techniques and concepts.

System Development Approach

Design objectives and the development method allowed ADANS to be quickly implemented, reliable, useful and acceptable to users. Previous systems had experienced difficulties during implementation which was largely attributed to extended time between specification and first delivery and lack of involvement of planning staff in design (Davis, C., 1991).

Given previous systems' difficulties and deficiencies and the operational environment of ADANS, developers quickly realised that several development goals were required:

1. To ensure that one malfunctioning portion of the system could not shut down the entire system.
2. To provide both graphical and textual procedures for editing and viewing data.
3. To provide an automated means for choosing default data or for generating results from limited data.
4. To support development of a system flexible enough to allow for quickly changing concepts and operational constraints, especially in the design of the scheduling algorithm and mission editor (Hilliard et al., 1991:5-7).

Development staff worked along side flow planners at MAC, providing continuous participation. "By working directly with flow planners, developers were able to see problems first-hand, to work directly with the flow planners to design solutions quickly and to

communicate needs to software development staff" (Hilliard et al., 1991:6)

The result of this partnership was an integrated system. MAC's flow planners could enter and evaluate cargo and passenger movement requests; manage information about aircraft availability, aircraft characteristics, aircrews, airfield resources, and airlift network configurations; develop a concept of operations; create mission schedules; analyse schedules; and communicate with MAC's command and control system.

Critical to the system's success was the cooperation of planner and developer. Where the system worked, planners were quick to identify with it. Where it did not, planners were prepared to better define their needs. Developers were prepared to align their efforts to priority needs of planning staff (Davis, C., 1991; Peterson, 1991). Intimate concern by executive management for the welfare of the system was also considered vital to the system's success (Davis, C., 1991).

Techniques and Processes

Interactive support to the planner during all stages of planning is attractive to the ADF. As the United States Armed Force's approach to airlift planning differs little from that of the ADF, little changes would be required for ADANS to port into the ALG planning environment.

Demonstration of the system to the author showed that the system reacted well to shortages of data concerning requirements. Global data concerning airfields and aircraft is imported from centrally maintained files, reducing time required to establish operations. Data on operations is segregated allowing planners, especially the deliberate planner, freedom to perform potentially destructive tests of plan

sensitivity without impacting on airlift under way. System defaults minimise the need for planner intervention in processing and allows for inexperienced staff.

Requiring the planner to define the available flow network establishes firm control over the scheduling algorithm, though an inexperienced user must be careful when interpreting results of modelling. The scheduling algorithm is timely and automated production of mission details from an approved schedule would significantly improve decision cycle time and, hence, responsiveness in large operations.

By allowing planners to modify network characteristics before and during implementation of a schedule, the system quickly and accurately supports sensitivity analysis. Planners can change parameters in response to changes in the operation environment and request rescheduling of aircraft. Not only does this support actual changes in the environment in a timely manner, it also allows planners to gauge robustness of schedules and evaluate how the schedule deteriorates with resource attrition.

Electronic communication of requirements and missions to other systems immensely improves MACs response time. Generated reports illustrated that system output is easily understood and is timely as well as supplying information that is not readily available in the present ADF system.

The text and graphical interface supports users with different computing background and skills. Documentation is well written, though only in draft. Finally, a fast response time improved user friendliness of the system.

Deficiencies and Drawbacks

ADANS suffers deficiencies in its overall control of airlift resources. ADANS has separate systems for unclassified and classified operations as well as peacetime airlift. Each operation is treated in isolation by the system and partitioned from other events. This allows what-if and scenario development sensitivity testing to occur without risk of affecting current operations because of operator misunderstanding.

However, this leads to a "stove piping" effect, where the system does not provide global airlift visibility between operations. This is understandable given the size and location of the airlift fleet and the United States Armed Forces doctrine that resources are usually allocated to theatre or force commanders for the duration of requirement. There are sufficient airlift resources to support more than one theatre of operations anywhere in the world, allowing planning and scheduling to be performed for each operation in relative isolation.

However, the ADF has a smaller airlift capability and a more localised and concentrated area of influence. Doctrine and planning provides for sharing of resources between force and theatre commanders. ALG requires a planning system that takes all resource commitments into account at planning and implementation stages.

Despite this deficiency, ADANS is a fine and highly capable system that is still evolving. In fact, it is too capable for the ADF to justify the cost of its acquisition. The system provides for scheduling of C141, KC10 and C5 military aircraft and numerous commercial aircraft. Australia lacks this range of airlift resources.

ADANS is designed to manage very large scale, multi-theatre and global airlift. This capability falls outside the goals of any airlift system for the ADF, whose area of influence is more localised (Dibb, 1990:17). The different doctrine and communications systems of the ADF would require significant rework of ADANS systems, especially the requirement analysis and validation system and the communications suites (Davis, C., 1991).

Finally, the system's cost would be difficult to justify by offsets in costs of airlift because of increased efficiency. Despite its deficiencies, the present manual approach to RAAF airlift planning works and a computer based system cannot be justified on the grounds of inability to perform airlift planning manually (Peak, 1991a:7 August). The system must provide sufficient improvement in effectiveness and efficiency to justify development costs.

Development cost of ADANS for the ADF would range between about US$10 million and US$17 million (Davis, C., 1991). Even assuming an ambitious five percent increase in airlift efficiency as a result of the system's implementation, the ADF would have to fly at least the equivalent of between US$40 million and US$68 million of airlift per year over five years to amortise the cost of development alone.

Canadian National Defence Airlift Planning

The Canadian National Defence Force, titled Canadian Forces (CF), is about the same size as the ADF and their nation is of similar size and demography. Operations, except those in support of Canada's commitment to NATO, are similar. ADF and CF doctrine are also similar largely because of shared ancestry. The effect of climate on

operations is as extreme and air is a vital mode of transport for operations.

"Although CF members are moved by all modes of transport, CF aircraft provide the primary means" (Minister for Supply and Services Canada, 1988:121). Founded in 1975, Air Transport Group (ATG) is responsible, to Air Command, for providing airlift support. ATG operates both fixed and rotary wing aircraft for transport and search and rescue assignments. Strategic transport aircraft include five Boeing 707s and 26 C130s. Additionally, ATG supplements its strategic airlift capability with civil aircraft charters (Krisinger, 1986:7).

Strategic airlift planning is performed manually and procedures used are similar to those of the ADF. Annually, a joint movements planning course is conducted to better prepare personnel, who have line exposure to movements, to principles and approaches employed in the planning of large scale movements of forces. The course improves basic skills and applies consistent approaches to airlift planning. However, as the course addresses all modes of transport, lower level mission planning and tasking activities are not addressed. The ADF would benefit from such a course.

CF strategic airlift planning suffers similar deficiencies to those of the ADF. Manual collection and collation of data takes time as does presentation. Little scope for efficient sensitivity analysis exists. Similar problems with timeliness and accuracy occur with distribution. Similarities between ADF and CF airlift planning systems and their deficiencies suggests that these deficiencies are a consequence of method, particularly its manual basis, and not due to

poor application or personality based conflicts (Peverley, 1990; Primorac, 1990).

Summary

Airlift planning involves four iterative activities; investigation, detailed static planning, implementation and dynamic management, and performance monitoring and review. As the planner progresses through each activity, the level of detail of information increases, building on results of previous activities. Planning culminates in flying and review of airlift.

Computer based solution approaches face problems with accurate and complete definition of the airlift environment. Problems facing the planner within each activity are well researched and many found to be hard. The largest problem, the scheduling of aircraft, is a generalisation of the pickup and delivery problem with time windows, where even generation of a feasible solution is hard. Nevertheless, computer application is possible through use of heuristics and constraint relaxation.

The ADF planning approach is manual and suffers deficiencies in poor data control, unnecessary repetition of structured tasks, lack of consistency in planning approach, lengthy learning curve for new planners, distribution delays and problems and lack of feedback of actual performance. Similar problems are suffered by the CF approach, which is also manual, though a movements planning course does encourage use of a consistent approach.

The USAF uses several computer based systems to assist their airlift planner. Principal among these is ADANS, a recently implemented

system that comprises extensive database, modelling and communications suites. With some rework, the system would meet most of the ADF's needs but its level of sophistication is not justified given the ADF's size or mission.

However, ADANS illustrates the potential of a computer based MIS to assist airlift planning and provides useful information concerning design approach and functions for an ADF system.

V. Proposed Airlift Planning System

Overview

The previous chapter investigated the activities and requirements of airlift planning. Deficiencies were found in the ADF approach, largely due to the manual nature of information management. Research of techniques for airlift planning and review of USAF systems provided direction on development approach and system design. The similarity of the CNDF to the ADF suggested that any proposed system could be generalised to the CNDF.

This chapter addresses the last investigative question, how would a RAAF computer based strategic airlift planning system operate? It presents a proposed computer based MIS for ADF airlift planning. As "the quality of a software product stems, in large part, from the quality of the process used to create it" (Humphrey and Sweet, 1989:221), time is taken to derive suitable development methods and tools. Discussion of the proposed system follows, including major features and development phases.

In Chapter VI, many advantages of the proposed system are claimed, addressing all deficiencies of the present approach. Feasibility tests of the proposed system and validation of improvement claims are also covered in Chapter VI.

Systems Development Methodology

The development process is the set of methods, tools and practices used to produce a product (Humphrey, 1990:3). The objective of development process management is to produce products according to plan.

Boehm has found that good development process management is synonymous with good risk management (Boehm, 1989:v), and there is growing attention to the confrontation of risk during development (Gilb, 1988; Humphrey, 1990; Boehm, 1989).

Risk has two components: "the probability of some event occurring and the adverse consequence of that event should it occur" (Edgar, 1989:282). In system development, adverse consequences include budget overruns, schedule slippage, wrong functionality, shortfalls in performance and reliability, incompatibility of hardware and software, failure to obtain all anticipated benefits, and poor quality software requiring high maintenance (McFarlan, 1989:17).

A systems development process must assist managers to confront and accurately access risk. It can do this by providing methods to evaluate likelihood and magnitude of adverse consequences, reducing likelihood or the cost of these consequences. Further, the process must document decisions made and the basis upon which they were made.

Unfortunately, there are many tools and methods available and "the contribution each device can make to planning and controlling a project varies widely according to the project's characteristics" (McFarlan, 1989:21). These characteristics include: project size, experience of the organisation and managers with technology, stability of the organisation, impact on the organisation, and contribution to corporate goals (McFarlan, 1989:20-21). "There is no universally correct way to run all projects" (McFarlan, 1989:21) and process managers must assemble a mix of devices that derive the most effective development processes for each development effort.

Development Methodology (Gilb, 1988)

An evolutionary approach was chosen for development of the proposed system. This method has "many stages of expanding increments of an operational software product, with the directions of evolution being determined by operational experience" (Boehm, 1989:28).

The method starts with a functional specification that lists essential things that the system must do and what must be delivered at specific times. For each function, attributes or constraint characteristics are defined. For example a functional objective of availability may include attributes of reliability, maintainability and integrity. During each step of development, ways of measuring attributes are defined, with values of worst, best and planned achievement. Steps of development hinge on delivery of product to end-users (Gilb, 1989).

With every development of an end-user component, users get the opportunity to evaluate and apply. Feedback from implementation is used to review the functional specification, improve definition of attributes for components and guide next development effort.

In essence, the evolutionary method is based on the principle of deliver something to a real end-user, measure the added value and adjust both design and objectives based on observed realities (Gilb, 1988:84). This method was chosen to guide development of the proposed system because:

1. it is multi-objective driven,
2. it encourages quicker returns to end-users,
3. it lessens likelihood of unsuccessful outcomes,
4. it provides an upgrade path to future enhancements,

5. it allows increased flexibility,

6. there is greater user-orientation,

7. critical components are considered earlier.

Multi-Objective Driven. ADF airlift planning is driven by many objectives. USAF experience shows that the best airlift planning systems were those that offered the best mix of products required by users and not those systems that exceeded user expectations in some areas but seriously neglected others. For example, even though the FLOGEN system offered sophisticated flow design, it failed because of its difficult user interface and inflexibility (Davis, C., 1991). Evolutionary delivery is based on iteration towards clear and measurable multi-dimensional objectives. "The set of objectives contain all functional, quality and resource objectives which are vital to the long term and short term survival of the system under development" (Gilb, 1988:89). Thorough and balanced assessment of all objectives decreases the likelihood of adverse consequences, especially those with highest cost.

Quicker Returns. In evolutionary planning, steps with the highest user-value to development-cost ratio are selected for early implementation. This offers quick return on investment to users, early demonstration of capability to deliver, provides better measures for risk assessment of later stages and gives earlier feedback on changing or newly defined system requirements (Gilb, 1989:89,91-92). As the tenure of ALG planning staff is between two and three years, quick delivery would encourage management involvement and allow continuity of staff during implementation of components of the system (Thyer, 1991). Additionally, as ALG manning is constrained, quicker delivery of gain

would be preferred as protracted analysis and design would tax personnel resources.

Lessened Risk. The method relies on many small steps of implementation. Engineering process management recognises that risk is more controlled when changes are small and, that feedback of results improves future performance (Gilb, 1988:301). Through earlier feedback of performance, smaller steps of implementation divide overall risk into smaller components and more rigorously appraise it in the presence of more information. This lessens risk exposure by reducing the likelihood and size of consequence.

Provided Upgrade Path. The ADANS system provides an ambitious goal for the proposed system. However, any development effort by the ADF would be by end-users. To embark on a system of similar sophistication to ADANS would be extremely risky given the level of technology involved, the number of iterations and amount of resources it took before the USAF was able to develop the system, and the skills of ADF developers. Yet, the evolutionary method allows ADF resources and desires to be accommodated through a formal plan to evolve from a system that meets immediate needs with low risk to a desired system state. High technology risk can be transfered to later stages, improving success during critical infant stages of development.

Increased Flexibility. ADF planners consider the airlift planning environment to be constantly evolving with the introduction of new concepts, resources and command structures (Peak, 1991a:2 July). ADANS development staff recognised that a similar environment existed in the USAF and attributed much of the system's success to flexibility during development. The evolutionary approach provides flexibility by allowing

iterative and small movement towards objectives that are expected to shift (Gilb, 1988:111).

Greater User-Orientation. With evolutionary delivery, the developer is charged with listening to user reactions early and often (Gilb, 1988:92). The user plays a direct role in implementation. ADANS developers found that airlift planning systems are successful only if end-users are involved in all stages of development (Davis, C., 1991; Hilliard et al., 1991:6). Not only does the evolutionary method allow this involvement, it provides for early user evaluation of progress and greater user involvement in future development direction.

Earlier Consideration of Critical Components. A MIS to support airlift planning will impact on critical activities of ALG and the ADF. Cost of some adverse consequences, such as data loss or unreliability, will be high and will be felt across the ADF. Therefore, executives will demand proof that likelihood of failure of critical system components is low before they will support development of the system. The evolutionary approach allows for early design and testing of critical system components, providing better quality information for risk assessment and reducing cost from failure of critical concepts. Desirable but higher risk development can be deferred during early stages of the system's life where user and executive confidence are typically low.

To confirm methodology choice, ADF airlift planners were surveyed for recommendations of development approach. Sixty-seven percent recommended an evolutionary approach for reasons of increased user control, limits in resources and improved likelihood of producing the desired product.

Tools of Analysis and Design

Having broken development into small and evolving steps, structured tools were required to help with analysis and design activities. Data flow diagrams and entity relationship diagrams were adopted because of their wide use in the ADF and the reliability of their technology.

A computer aided software engineering (CASE) system, EasyFlow™, was used to improve presentation quality of diagrams, decrease time to incorporate amendments and allow electronic interchange if required for later RAAF development effort.

Prototyping was adopted as a test method to reduce risk of developing the wrong software functions or user interface and straining computer science capabilities (Boehm, 1989:344). Using Carey and Mason's classification of prototype methods (Carey and Mason, 1989:350), a working model prototype was used for the proposed system because, under the evolutionary method, it is likely that this form of prototype would represent the initial evolution of system components (Carey and Mason, 1989:354). Designing possible increment one versions of critical components helped validate claims of feasibility and improvement. Additionally, potential exists for use of the design effort by the RAAF.

Development Software

Prototype requirements called for software to manage and manipulate data on DOS based hardware. The prototype used a commercial database management system for reasons of compactness of stored data, speed of retrieval, reduced primitive coding burden, concurrency and multi-user support (Date, 1990:13-14). As "almost all database products

developed over the past few years are based on the relational approach" (Date, 1990:22), this method was chosen.

In a relational database management system (RDBMS) data is perceived by the user as two dimensional tables that represent both data and relationships. Borland International's Paradox™ RDBMS was used because of its high rating against other personal computer RDBMS systems (Product Profiles, 1991; Miller, 1990; Readers' Choice Awards, 1991:133), large market share (Software Saleswire, 1991:92), and financial stability of the company (Fisher, 1991).

A hypertext system was also required for on-screen user help. Hypertext is a three dimensional system for representing information to users. Unlike conventional text managers, hypertext allows text to be not only linked to the text immediately surrounding it but also to definitions and graphics. Ntergaid's HyperWriter!™ was used because of its ease of use, reasonable performance and simple linking into the database system.

Proposed System

The proposed system, the RAAF Airlift Planning System (RAPS), is a MIS providing computer based decision support to the airlift planner. It maintains global and operation specific data in a reliable and related form that is available to many users. User interface is based on a combination of form and menu environments.

RAPS assists semi-structured decision making by providing an interactive environment for the matching and scheduling of resources to requirements. Structured tasks are performed by the system, though users may override decisions made. It provides proofing of planning for

issues including ramp capacities, flight times, turnarounds, over commitment of resources, requirements not met and flow schedule timing conflicts.

The system produces air mode instructions and other reports. Additionally, the system provides for individual management styles through seamless porting of data to spreadsheet, graphics and other commercial software. Appendix E contains the RAPS functional specification.

Major System Components

In accordance with the development method, a modular design best describes the system's architecture. This approach allows design of sub-systems in isolation, improves maintainability by applying "black-box" concepts and takes advantage of natural boundaries between tasks within the system's environment. Rigid interface specifications allow discrete components to mesh to appear as one entity to the operator, even though different systems and lower level application languages are performing tasks.

RAPS is "IBM PC" micro-computer based. Not only does this choice give access to low cost and tested computer technology, it allows for portability of hardware and availability of the immense amount of commercial software that has been developed for the micro-computer market. By maintaining data centrally and using local and wide area networks (LANs and WANs) to provide interconnection between users and data, data integrity and control will be improved without cost to user access.

RAPS has five functional components: control, dialogue, data, models and communications.

Control

The control component provides overall control to the system through session control and system management. Session control includes system start-up and user log-in control, access security, top level branching between system components and shut-down activities. System management addresses establishment and removal of operations, back-up, data import and export, security definition, and other miscellaneous housekeeping activities.

The control function can be provided by any software, though access to a database and user interface is required. Control represents less than five percent of the overall system but is critical as it provides primitive connection and interface between users and other system components. However, requirements and capabilities of initial and intermediate design evolutions will be basic, reducing the level of technology and sophistication required. This suggests a high likelihood of successful development.

Later evolution of the system towards multi-tasking within RAPS, intricate user interfaces and distributed processing may increase complexity of control and hence likelihood of unsatisfactory outcome.

Dialogue

Dialogue functions address the interface between RAPS and users. Users of RAPS are expected to vary greatly in computer familiarity. Highlights of the dialogue component of RAPS are:

1. A simple interface is provided to users. This interface will be tailored to the needs of the different classes of users based on familiarity with RAPS.

2. A menu and form driven dialogue is used. Standardised process steps and consistent screen layouts, colours and titles are used across all transactions. While assisting overall user familiarity with the system, greatest benefit occurs with infrequently used transactions. Where users are presented with a choice from a number of candidates, look-ups are provided.

3. A hypertext sub-system provides on-line help and training to users, without users leaving the place in the system. All menus allow access to helpful information relating to the current activity and menu choices.

Graphics based interfaces are increasing in popularity because they allow users to visualise complex information as a whole, by use of patterns. However, inconsistencies in interpretation between individuals occur, there is no consensus of what aspects of interface are best suited to graphical display, and little standardisation between graphics systems exists (Turek, 1988).

Alternately, text based dialogue systems are well tested and reliable (Turek, 1988). As airlift planning is largely number orientated, a text based system which uses graphics based help and learning would provide sufficient interface with low risk. Hence, this approach is adopted for early, if not all, design evolutions.

Graphical interfaces, such as provided by the ADANS, require more technology and program sophistication and hence, introduce greater risk. This interface is best considered later during the system's life, when

related technology is more proven and standardised and RAPS is established. Natural language and lexical interfaces would introduce extreme risk given their technological infancy.

Dialogue functions represent 20 percent of the system, though this ratio could increase if later evolutions adopt more sophisticated interface standards.

Data

The ALG planning function requires data to be maintained on many operations and to be accessed by more than one person simultaneously. A database system is required to store relevant information concerning airlift planning in a logical and related way. Its reliability and performance is critical to the system and is expected to represent about 30 percent of mature system development.

A system using a generic commercially produced RDBMS shell is most likely to meet all requirements with least risk. This approach has proven reliable and effective for the ADANS development.

A centralised database system will be used for early design evolutions because of reduced risk and little need to distribute data given the centralisation of ALG airlift planning staff. Mature evolutions of the system may move RAPS towards a distributed database as users of data become distributed because of ADF organisational changes. Benefit to users will have to be high to warrant the risks involved unless the reliability and sophistication of microcomputer based distributed database systems improve.

RAPS data is defined as either global or operation specific. Global data concerns: characteristics of resources, such as airfields and aircraft; characteristics of requirements, such as unit names,

addresses and payload types; and RAPS management data, such as user and operation descriptions. There are single instances of global data, while each operation requires its own specific data on missions, payload and requirements.

Models

RAPS models provide semi-structured decision support to the airlift planner. Though the stepping stones to improvements in airlift planning performance, few RAPS models are critical to initial development. Exceptions are the mission and payload editors.

In accordance with the development method, models will be developed when user needs make this attractive. Thirty percent of mature RAPS development is likely to be devoted to decision support models. Though level of model sophistication will be determined by user need, evolutions from basic to more sophistication is important risk minimisation approach. Likely preference by users for interactive models will also reduce risk.

The following are envisioned for the system:

1. Mission and payload editors will allow users to define and amend missions, and the payload they will carry. Structured tasks that are part of the editing process, such as keeping payload linked to mission legs and calculating flight times, will be provided by the system.

2. An airlift estimator that analyses requirements, estimates loads by aircraft type and predicts resource needs and airlift duration.

3. An a priori airlift flow router and schedular that derives a flow to meet requirements.

4. A dynamic airlift flow router and schedular that adjusts airlift under way in response to environmental changes.

5. A mission payload analysis system that will assist the building or changing of payload for missions.

6. A proofing system that reviews operation airlift flows for conflicts in flights and over commitment of aircraft and airfield resources. Analysis of airlift for flow improvements and under utilisation of missions will also be provided.

7. Globally based models that analyse overall ALG airlift for executive and intermediate resource managers.

8. An operation review system that derives air mode instructions and produces statistics on airlift planned, under way or finished. For planned airlift, potential is summarised, while later reviews match actual against expected airlift performance and compare overall performance with other airlift efforts and executive requirements.

9. An archival and retrieval system to store past operations, build abstracts of airlift performance and allow executives and planners to quickly develop an airlift operation scenario based on past operations.

Communications

At some time during evolution of RAPS, electronic transmission of airlift data to ALG and outside agencies is expected to become attractive to end-users for reasons of timeliness, security and accuracy. Communications suites envisioned for the system will support:

1. receipt of requirements from mounting authorities;

2. transmission of load estimates to air terminals, return of draft load plans from terminals to ALG, and confirmation of acceptance of load plan to terminals;

3. transmission of air mode instructions from ALG to mounting authorities and ALG agencies;

4. transmission of actual load and task detail from terminals and operating squadrons to ALG;

5. transmission of actual lift summary to mounting authorities and higher command;

6. e-mail (electronic message transfer) connection between ALG staff and operating squadrons and terminals;

7. transmission of mission requirements and summaries to intermediate maintenance squadrons and higher command; and

8. transmission of manifest details from ALG to terminals and return of turnaround summary.

Technological risk associated with data communications and lack of control over external agencies will contribute to development risk. Although mature communications components are expected to be sophisticated and represent 30 percent of development effort, initial components will be simple.

Development Phases

The evolutionary development method calls for implementation choice to be based on user needs and for implementation steps to be frequent and gradual. While this approach is being applied to RAPS, likely development phases have also been identified. These phases plot expectations of larger development activities and reflect user's desires.

Though these phases are subject to constant change by the development method, they are useful for securing resource allocations given the long lead times required to secure ADF funding, manning changes and higher computing committee approval. Additionally, these

phases provide users with development timings and sequences where risk has been minimised, which suits most, especially executives who expect thorough and detailed planning.

User needs were gauged by a survey of ADF planning staff. As shown by Appendix F, ranking highest in needs, with 71 percent of planners rating it as important, was the development of a database system. Next, with a 57 percent importance rating, was a routing and scheduling tool for planners, though planners disagreed over level of automation required. Effective communications with ALG and external agencies rated third, with 43 percent. An executive support and statistics system secured 14 percent planner support as did an auditing system.

Reacting to these needs, the first evolution of the system includes six phases or increments.

1. the transaction and task planning level, including load estimation, mission and payload editing and flow reporting,
2. planning decision support systems,
3. connection to ALG agencies,
4. executive and review systems,
5. connection to mounting authority and other modal components, and
6. an enhanced deliberate planning system.

Increment One - Transaction Planning Level

The first increment concerns the minimum development needed to move ALG airlift planning from its manual base to a MIS. While minimising commitment in the interests of risk reduction, enough has to be done to demonstrate clear improvement to users and executives. Success of this increment is critical. Otherwise, customer enthusiasm

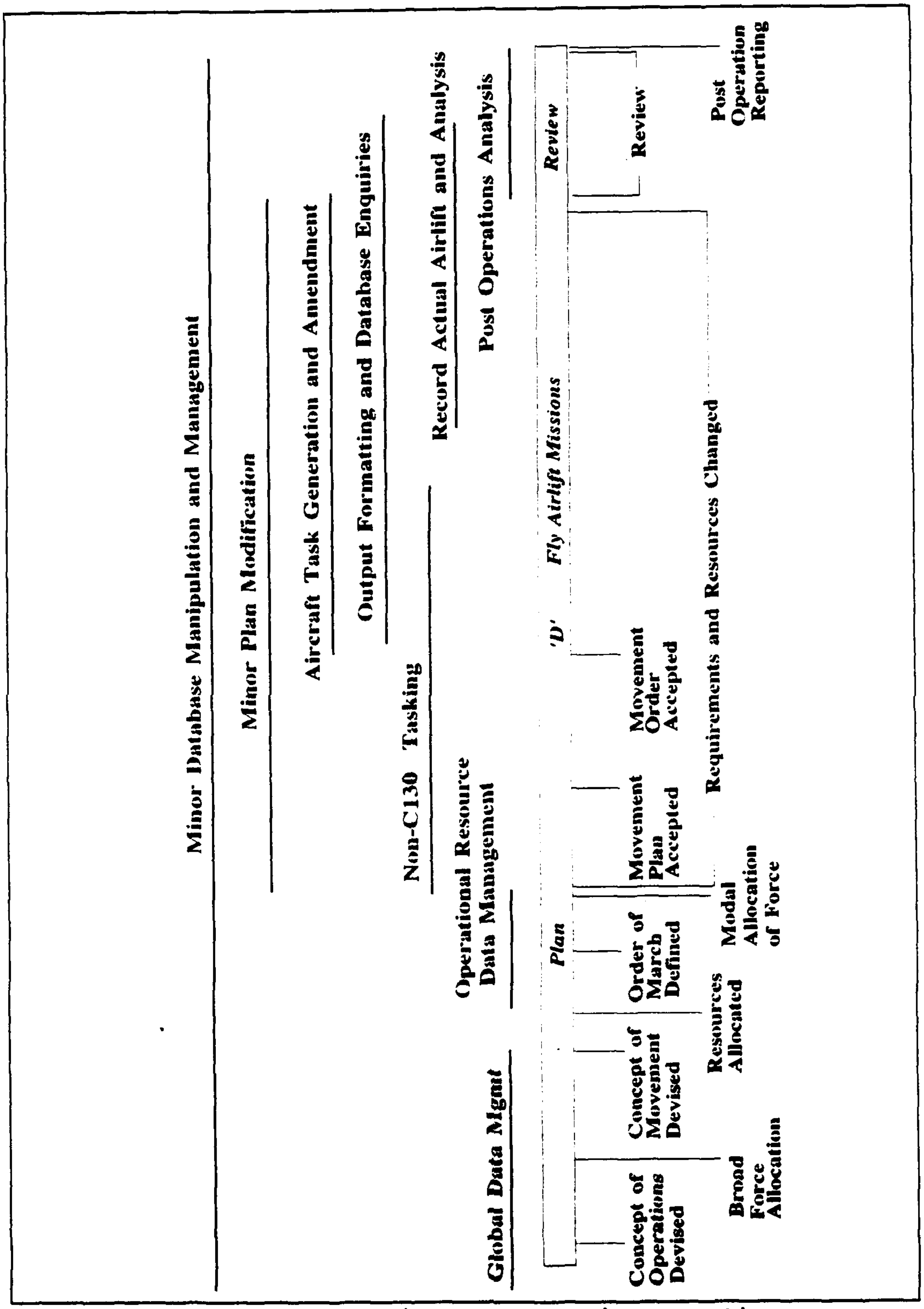

Figure 5-1. Increment One Functions Mapped to Wider Operation Milestones.

with the system will languish as will resource allocations and user support.

Efficient database management for operations is the target for increment one. Mission and payload editors will allow users to quickly add and modify airlift tasks. Structured decisions and calculations will be performed by the system and the system should offer flexibility in mission building approaches. Mission and payload data would be tied transparently to the user. Air mode instructions and other reports will be available in electronic or hard copy form.

Appendix G contains a discussion of a prototype of the transaction planning level while Figure 5-1 shows the functions of increment one plotted against wider operation milestones.

Increment Two - Planning Decision Support Systems

Increment two will target decision support systems for the airlift planner. While increment one assists the planner at the mission and payload level, increment two supports decision-making over all missions in an operation.

Principal development effort will be towards a model to assist the scheduling of airlift. Research indicates that greatest potential improvement from automation of airlift planning may come from this area (Bodin et al., 1983:70). However, there is no general purpose commercial software available for this area (Bodin et al., 1983:189).

Lack of proven products and model requirements that are complex suggest higher likelihood of deriving a model that is wrong or falls below user expectations. Yet, development of a router and schedular rated second in importance to ADF planners.

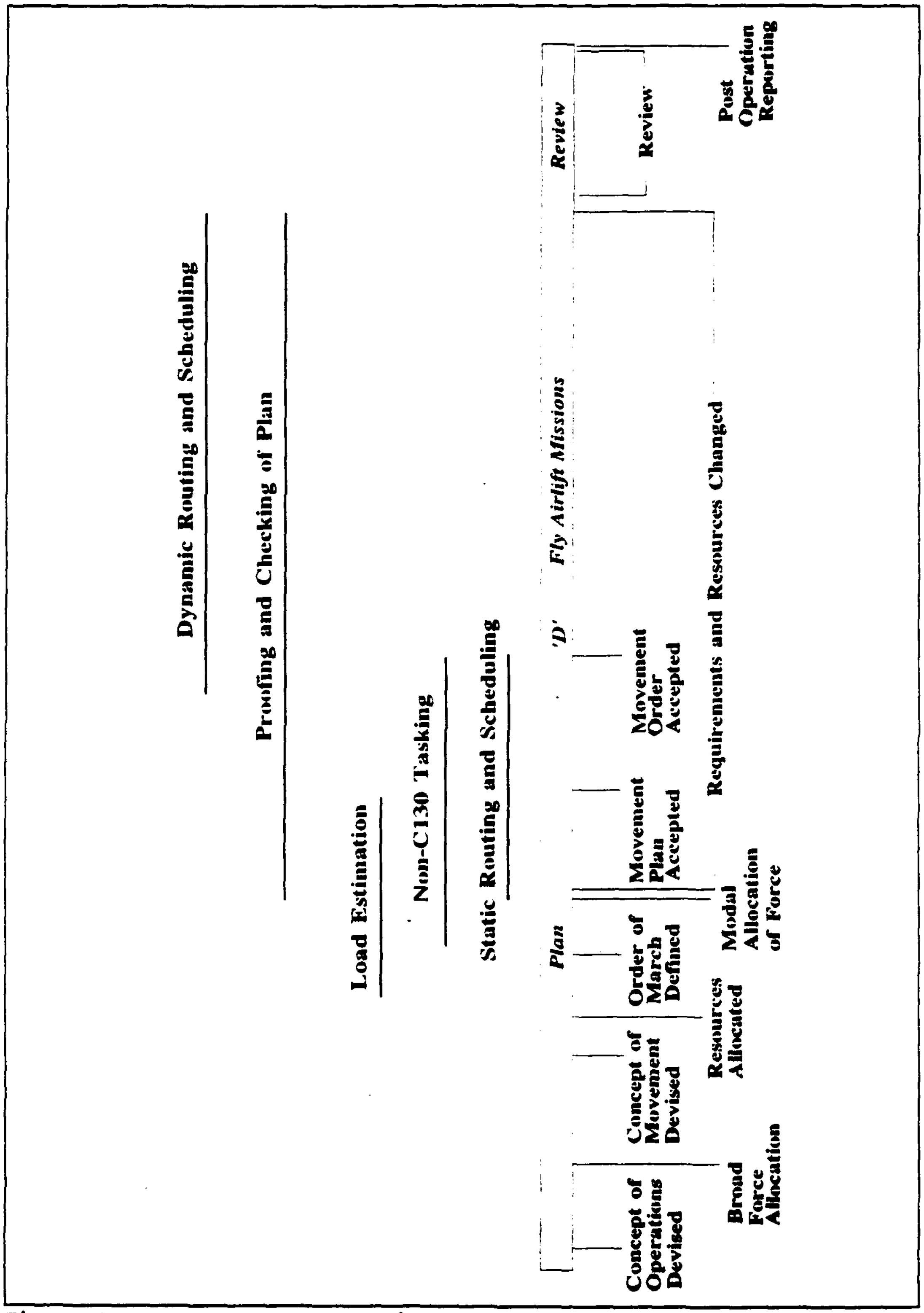

Figure 5-2. Increment Two Functions Mapped to Wider Operation Milestones.

The level of user support and likely immediate and potential improvement justifies early development of a router and schedular, in anticipation of on-going improvement in sophistication of scheduling models. Several evolutions are expected before maximum advantage to airlift planners from a routing and scheduling system will occur. Appendix H defines the RAAF scheduling problem and an initial solution approach to a constrained problem.

A model to assist load estimation will also be developed. Its risk is lower as is its potential. Figure 5-2 shows the influence of increment two functions on wider operation milestones.

Increment Three - Connection to ALG Agencies

This increment aims to improve communication between airlift planners and airlift operators thus improving accuracy of planning information and making seamless the transition from planning to implementation. Additionally, improved timeliness of advice to agencies and quicker response to planning requirements are expected. Figure 5-3 provides the plot of increment three's functions against wider operation milestones.

Three ALG agencies are targeted: flying squadrons, intermediate maintenance squadrons and air terminals. Connection to flying squadrons will reduce time taken for planners to advise mission tasking changes and payload tasked to flights. Quicker advice from squadrons of actual flight hours consumed by missions, problems encountered, and recommendations for future similar airlift will also be possible. For maintenance squadrons, quicker advice of aircraft requirements should improve efficiency in aircraft and maintenance personnel use.

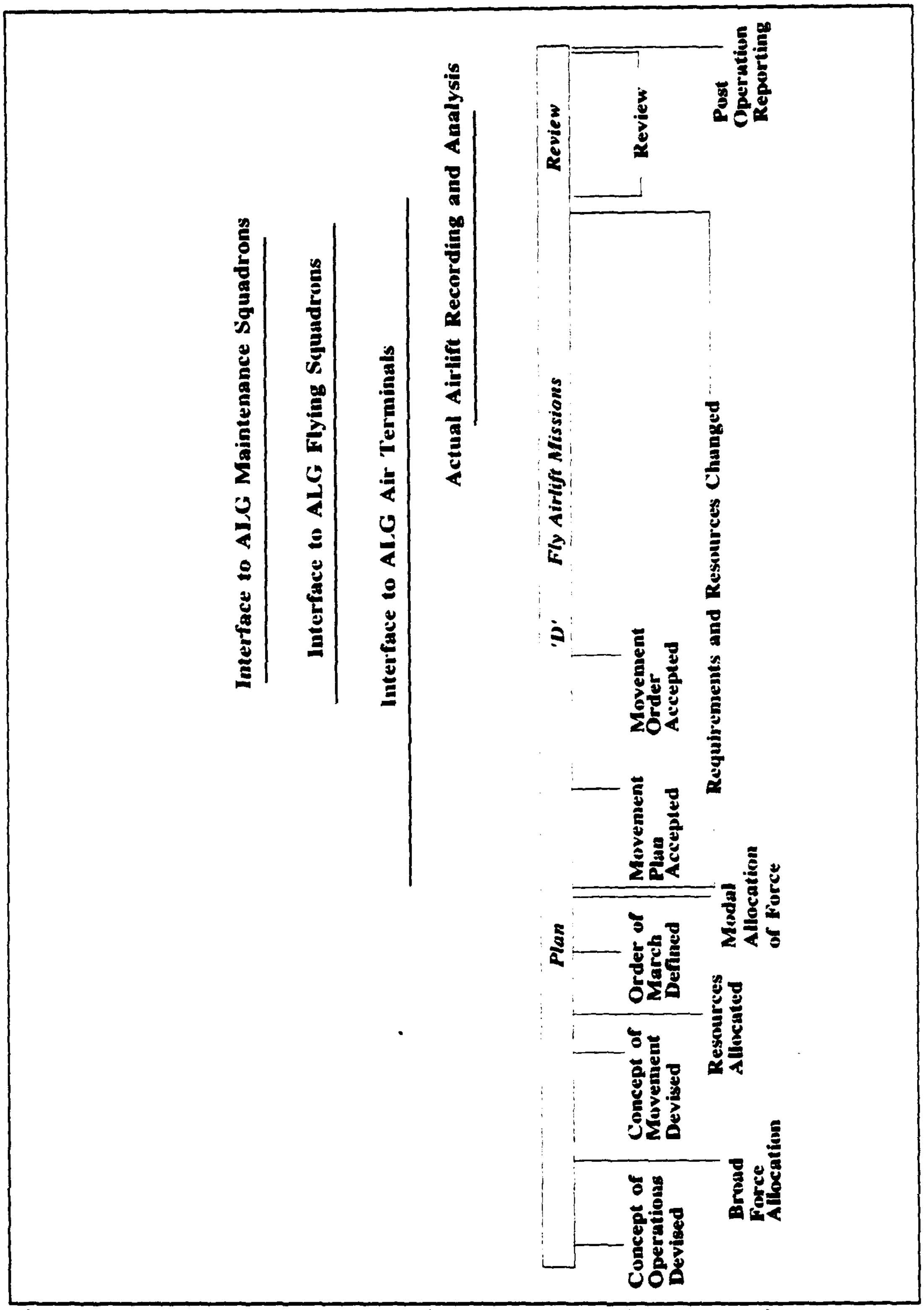

Figure 5-3. Increment Three Functions Mapped to Wider Operation Activities.

Additionally, earlier advice of inability to meet aircraft requirements will occur.

Greatest benefit of this phase is expected from connection to air terminals. Unlike ALG squadrons, terminals are remote to ALG and presently suffer problems with timely transmission of secure information which this restricts their involvement in the planning process. Yet, airlift planning accuracy and overall airlift effectiveness is improved if ALG's representatives at customer locations, the air terminals, are involved in planning.

Improved development of communications with air terminals will allow their greater involvement. After the load estimation phase, air terminals will be tasked with confirming estimates and providing detailed load summaries for missions. Air terminals are better able to perform detailed load planning than airlift planners because of their direct contact with movement control agencies and airlift customers.

In turn, air terminals will be able to electronically transmit load plan graphics back to airlift planners. Load plans will be electronically stored and linked to planned payload for each mission leg. This will significantly improve reliability of load estimates and information available to the airlift planner when considering amendment to mission payloads in response to changing requirements.

When meeting a lift requirement, the planner must estimate the number of loads required by aircraft type. Presently, this estimate is not reviewed until aircraft are tasked and loads are presented for uplift. Where changes to the airlift flow are necessitated, little time is available to analyse alternatives and advise all agencies affected of decisions made.

Under RAPS, planners would advise load estimates to departure terminals during static airlift planning activities. Terminals would liaise with customers and commence detailed load planning. Upon completion of load plans, they would be electronically transmitted to ALG planners. Planners would review load plans and record capacity unused. Whenever requirements change and load estimation must again occur, planners will have immediate access to load plan graphics and spare capacity data, allowing rapid and accurate incorporation of new requirements into existing airlift.

Besides improving the quality of payload planning, better communications between airlift planners and air terminals will reduce problems presently experienced when airlift moves from planning to implementation. As air terminals have responsibilities at the detailed static planning stage, they are better able to anticipate problems during implementation and able to solve minor problems locally, reducing the burden on planning staff and improving airlift response.

Initial versions of this increment may limit sophistication of communications to minimise risk. Sites may be connected by as little technology as a facsimile machine linked by a secure network to RAPS. RAPS would include commercial software to send load estimates by facsimile message and receive load plan graphic responses in facsimile form. Graphics format may be converted and linked into the RDBMS.

Later evolutions will move to on-line connection by remote sites with processing capacity. Where agencies lack sufficient computing hardware to accommodate RAPS needs locally, LANs supporting micro-computer nodes and an outgoing link to RAPS will be required.

A commercial e-mail system would then be the likely software vehicle for inter-agency connection as e-mail technology is improving and becoming more reliable (Tanenbaum, 1989:546-547). In response to database action by ALG planners and agencies, RAPS would extract data, format messages to relevant destinations and pass text and graphics based messages to the mail system for address routing and transmission. The same mail systems would present mail to destination RAPS systems.

Risk is higher at this phase. Likelihood of poor availability is increased by the proliferation of hardware as well as the move to distributed databases and graphics data management. However, industry progress in this area is high and time between failures and overall performance of distributed systems are increasing (Ahituv and Neumann, 1990:355). By evolving development through degrees of sophistication, technology based risk can be significantly reduced.

Secure electronic transmission is critical to this increment. ALG has already recognised this need and most agencies are linked to the Defence Integrated Secure Communications Network (DISCON) (Heap, 1991; Peak, 1991a:4 July). Issues of confirmation of mail receipt, automatic management of delinquent responses to planning tasking and legality of mail as official correspondence will require attention.

Increment Four - Executive and Review System

Increment four will address executive definition of early operation scenarios and the measurement of performance during and after airlift. It will build on advantages of greater and more timely data access derived at increment three and impact on early stages of airlift definition, as shown by Figure 5-4.

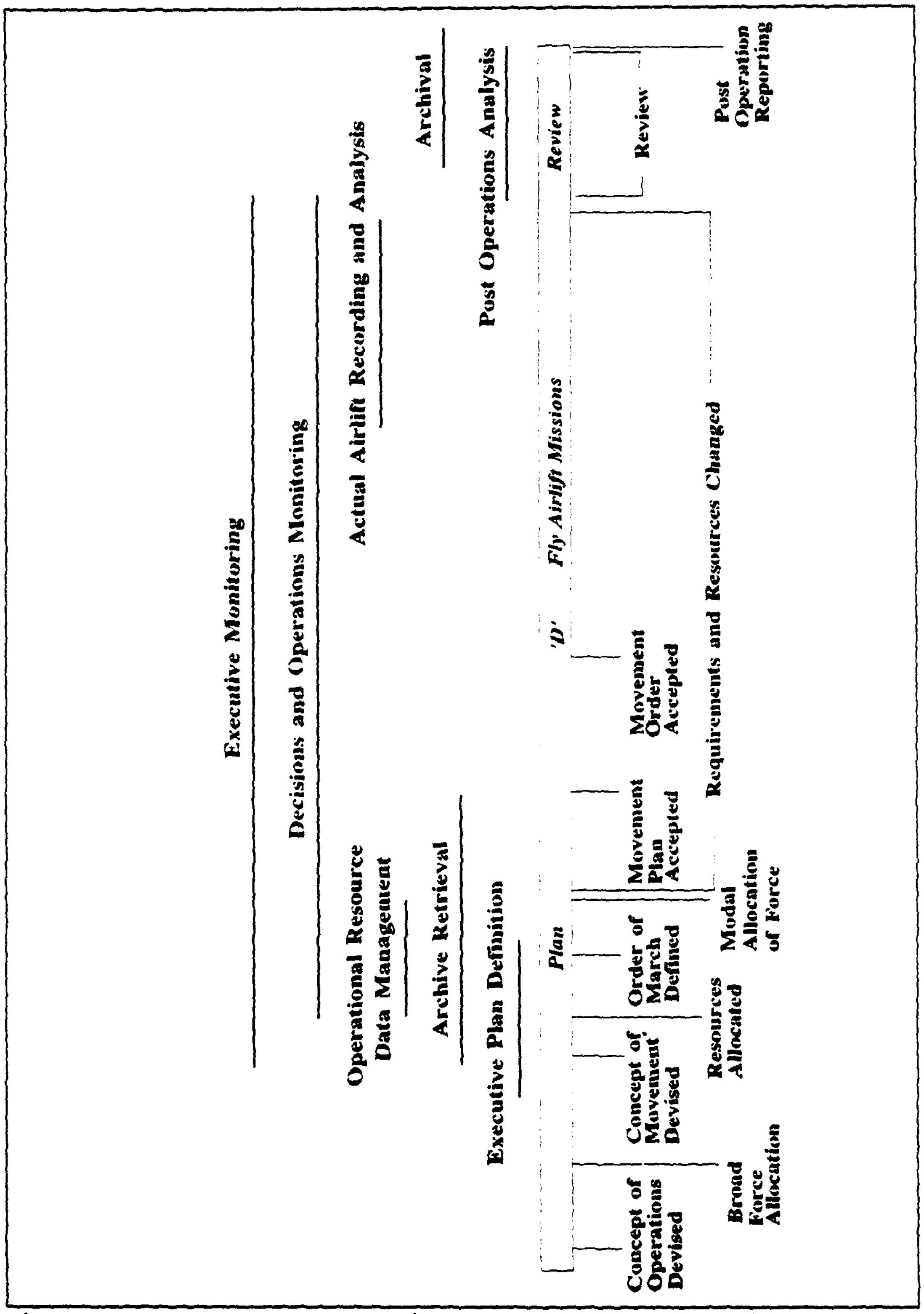

Figure 5-4. Increment Four Functions Mapped to Wider Operation Milestones.

With increases in accuracy and timeliness of actual airlift reporting, more attention to the review process is warranted. Models will be developed that examine airlift performance and cost. Useful reports will be produced both during and after airlift activities. These reports will assist planners in future decisions during the operation, provide information for post operation reporting and improve planning concepts and processes in future airlift operations. User defined metrics will be monitored and users and executives advised as necessary. Post-operation reporting time and effort for the planner will be significantly reduced while accuracy will be improved.

Currently, executives have little support for decisions they must make at early stages of airlift planning, such as resource allocations of flying hours and aircraft type. With improved measurement of previous airlift performance, RAPS could assist the calculation of likely resource needs and time limits based on executive definition of airlift scenario.

Firstly, a standard form of historical recording of past airlift operations will be derived based on operation scenario factors such as size, duration, location, threat and ADF units involved. With this base, models could assist ALG executives to define future airlift operation goals and accurately answer higher command questions concerning airlift capability. After executives have settled on airlift operation goals, RAPS would establish the operation, commence automatic executive reporting on planning progress, and prepare for detailed airlift planning.

In the short term, review is not as critical to airlift as activities of the transaction level. Therefore, cost of adverse

consequences is expected to be lower, reducing risk in areas such as performance and reliability.

However, wrong system functionality is more likely given the uncertainties that exist at the strategic level of planning and management. Additionally, users are wary of computer based monitoring and review systems and metrics that can be effectively applied to all airlift operations are difficult to derive. Lastly, with the move from the transaction level to the executive level of airlift planning, greater diversity exists in ways of individuals. Development must be careful to involve users in definition of requirements, maximise flexibility to managers in application of monitoring systems and merge the needs of all levels of management and all types of managers.

Increment Five - Connection to External Agencies

Timeliness is an important criteria in airlift planning. Previous increments have targeted improvements in the timeliness and accuracy of the airlift planning process. This increment aims to improve speed of communication between the airlift planning process and external agencies. The increment's functions are shown at Figure 5-5.

External agencies are of three types: operation mounting authorities, higher command and movement control agencies. Improved access to mounting authorities will give ALG quicker access to changes in requirements and bring the airlift planning process closer to force commanders. Using electronic transmission of requirements to RAPS, development during this increment would improve requirement validation turn-around time, security of transmissions, and the cohesion between mounting authority and airlift planning systems.

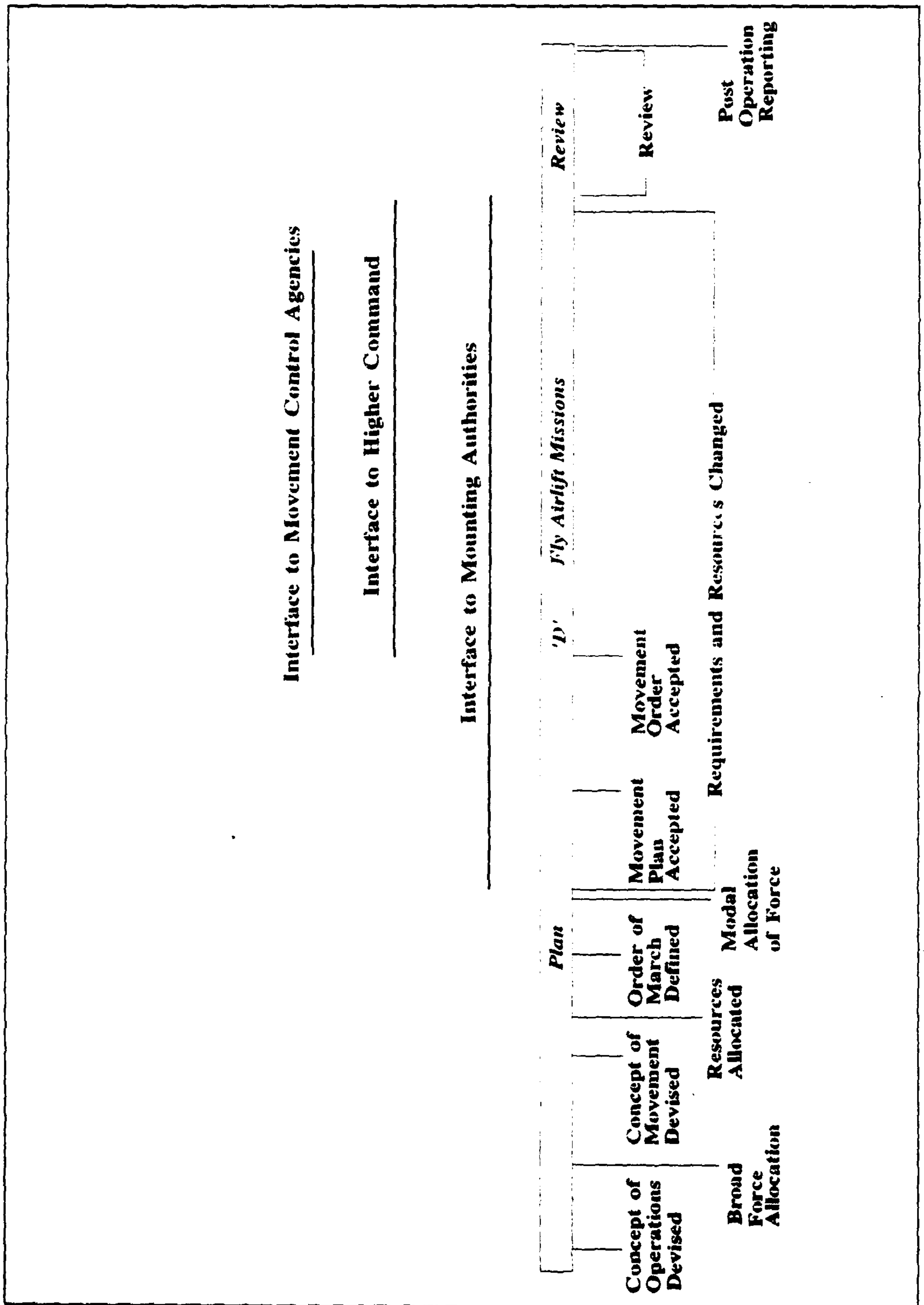

Figure 5-5. Increment Five Functions Mapped to Wider Operation Milestones.

Air Command has responsibility for effectiveness of ADF air assets in operations. A computer based command and control system is used to keep the Air Commander informed of operational developments. Currently, airlift actions are reported manually to the system. This increment would develop an electronic link between RAPS and the Air Command system to reduce ALG staff time spent reporting decisions and airlift state. In return, RAPS would receive information requests from Air Command and updates on actual flights.

Movement control agencies maintain actual airlift statistics at airfields not manned by an ALG controlled terminal. This data is required by RAPS to improve accuracy of information concerning performance and likely redeployment requirements. Increment five would establish an electronic link between RAPS and the Headquarters Movement Control element for larger operations. Actual payload airlifted would be e-mailed to RAPS which would automatically link this data to planned mission and payload information.

Increment five exposes the system to high risk because external agencies are involved and most of their systems are still in conceptual or early development stages. Currently, its high risk outweighs its advantage to airlift planning staff. However, higher ADF requirements are likely to force development in this area. Risk should reduce as better definition of external agency systems and requirements become known.

<u>Increment Six - Enhanced Deliberate Planning System</u>

The needs of the deliberate planner differ from those of the normal airlift planner. The deliberate planner seeks greater sensitivity analysis of airlift options. Additionally, airlift resource

constraints are softer. Increment six aims to support deliberate planning decision making by first applying standard measurements to past operations. At present, wrong or ineffective functionality in this task appears high though development in previous increments should reduce this.

With a standard definition of airlift capability across past operations, the next step would be to support extrapolation of past airlift to derive airlift potential based on similar circumstances. Through efforts of consistency, correlation and extrapolation, this increment attempts to improve the value of past airlift operations to the derivation of proposed scenarios.

Summary

This chapter described a proposed MIS based system to assist RAAF airlift planners. To manage development risk, a process methodology was devised, based on an evolutionary approach. The evolutionary approach was chosen because it addresses multi-objective requirements, encourages greater user involvement and delivers quick returns to users.

The proposed system includes functions of control, dialogue, data, models and communications. Constantly seeking ways to meet user needs with minimum risk, proposed system development steps would be frequent though gradual, moving in evolutions towards that desired by users.

Initial development of the system is likely to include six evolutions. Based on surveyed user needs, a database system and mission editors are required first. Next, models to assist the estimation of airlift requirements and the routing and scheduling of airlift would be developed. With planning capability in place, planning performance

feedback would be improved by an increment that addresses aspects of audit and review.

Development then seeks to increase time available to planners by improving communications to ALG and external agencies. Other increments address needs of planning executives and deliberate scenario planners.

The next chapter reviews the proposed system. The first increment is rigorously tested to provide support for a discussion of improvements offered by the system.

VI. Validation of Feasibility and Improvement

Overview

Previous chapters led the research through an analysis of what constitutes the strategic airlift planning process, how it is performed and what computer based approaches are available to assist airlift planners. This formed the base for the design of a proposed MIS to assist RAAF airlift planning.

This chapter tests the proposal. A prototype, developed for increment one of the system, is used to show system feasibility and confront risk for this and subsequent increments. Performance results of the prototype are used to support wider claims or improvements to airlift planning. Lastly, bottom line improvements in effectiveness and efficiency are appraised.

Prototype Testing

Increment one is critical to RAPS development because it is the first evolution to confront users and provides the data and control basis for future increments. It must bring direct benefit, while meeting functional specifications of user friendliness and availability. As risk associated with increment one had to be minimised, a prototype was used to model capabilities and user interface while providing better quality information on likelihood of adverse consequences.

Besides definition and creation of database relations, the prototype included approximately 100 screen layouts, 60 reports, 5 000 lines of RDBMS code and a complete help hypertext system. The prototype performed most activities required by increment one and basic load

estimation modelling of increment two. Appendix G provides an overview of the prototype.

The prototype was tested by the sponsor of this research using actual past airlift operation data. Hardware limitations forced the system to be tested on single-user hardware. However, multi-user access was allowed in the design.

The prototype met all transaction and data storage requirements of the airlift planner and the sponsor believed that "there would be few problems selling the system to ALG on the basis of improvement to airlift planning efficiency and effectiveness" (Peak, 1991a:5 July).

Although the sponsor received little training prior to using the system and despite it being the first time the sponsor had seen the system, he had few problems with system functions. The hypertext on-line help provided good support for transactions that had not been seen before.

Time to perform repetitive transactions was the greatest improvement. Time savings on some repetitive transactions were measured and are presented in Figure 6-1. Had the system been applied to a medium sized operation, a 31 man day saving was possible in these transactions alone.

Automation of structured tasks improved accuracy of actions and allowed more planning time. Structured tasks performed included production of air mode instructions based on various criteria, searches of the database for specific flights or customer units, calculation of mission times, cascading of changes to flights and mission numbers to payload data and local time calculations from zulu mission time.

Action	Manual Time (Minutes)	RAPS Time (Minutes)	Improvement (Percent)	Total Saving (Mid Size Operation)
Mission Orientated				
Add one mission	15	2	86	520
Amend a mission	10	1	90	1440
Move mission to a new month	22	2	91	200
Add *multiple flights* (time per flight)	10	0.5	95	380
Payload Orientated				
Add a payload unit	5	2	60	480
Amend a payload unit	2	1	50	320
Move payload to a new mission	7	2	71	400
Add payload multiple missions	10	2.5	75	300
Produce Air Mode Instruction				
Total Instruction	360	10	97	1400
Instruction by customer unit	20	4	80	1280
Instruction by location - to	60	4	93	1344
Instruction by location - from	60	34	93	1344
Estimate Loads				
Total operation	960	180	81	780
Rework estimates	480	10	98	4700
				14888 min 31 man-days

Figure 6-1. RAPS Prototype Time Improvements.

Greatest obvious improvement through automation of structured tasks was considered to be in mission tasking and amendment. The system's ability to calculate flight times based on great circle distance or pre-defined times, derive local times and calculate check digits significantly improved quality and accuracy of mission tasking. A feature that allowed new missions to be created by replicating an existing mission to a different day, week, fortnight or month based on the date or day of the week was considered impressive. This feature was also supported by capabilities to join and split missions.

The only unstructured task considered by the prototype was the estimation of load and airlift requirements. Though incomplete the model significantly improved the time taken by the sponsor to derive estimates of requirements and the accuracy of these requirements. With improvements recommended during appraisal by the sponsor, it was considered that the model would provide good assistance to experienced planners and be vital to inexperienced planners.

A crude graphics capability was included in the prototype to allow load plans to be viewed whilst in the system. This improved time to make payload allocation decisions and indicated that maintenance of load plan graphics by the system would be valued by users.

RDBMS maintenance of data was recognised as a major benefit. The sponsor considered that this improved his ability to involve more than one planner in an operation, improved consistency of data across operations and allowed planners to standardise planning figures. The ability to cascade changes across operations, missions and payload data improved data integrity and accuracy across missions and operations.

The ability to post a message against an airfield, customer unit or aircraft type that would be presented to all planners accessing the particular entity was considered an improvement. It allowed changes in capability or requirements to be quickly and accurately advised to all planners.

Overall System Feasibility

Infeasibility could only result from airlift planning not being able to be computer assisted or the system proposed not being possible with current levels of technology. Every ADF airlift planner surveyed considered that not only would automation assist them in their duties but that a system was clearly justified for the ADF. The success of ADANS further justifies confidence that airlift planning can be assisted by a computer based MIS.

All RAPS development increments can be accomplished with technology currently available. Further, early increments only use technology that is proven and reliable.

Overall System Improvements

RAPS is expected to offer the following advantages:

1. reduced data redundancy,
2. reduced data collection,
3. greater data integrity,
4. greater portability of data and planning activities,
5. shared data access,
6. faster communication of airlift planning and changes to customers and mode operator components,

7. improved security of data and communications,

8. establishment of a logical data flow through the airlift planning system,

9. improved recognition and resolution of airlift conflicts,

10. improved load requirement estimation,

11. improved routing and scheduling of airlift,

12. improved reaction time of airlift,

13. improved auditing of actions,

14. greater review of planned airlift against actual airlift,

15. improved decision cycle time,

16. greater involvement of ALG agencies in airlift planning,

17. improved connectivity to external agencies, and

18. improved executive support.

Reduced Data Redundancy by Shared Access

Under the present approach, each planning section has its own private files, leading to considerable data redundancy. Planners desire improved data management and better access to data (Newcombe, 1991:18 July). RAPS application of a RDBMS allows corporate level data management, where data is integrated and shared (Date, 1990:6). Data is either held in one place or redundancy is tightly controlled to ensure updates are propagated to all versions (Date, 1990:15).

Unlike the present approach, data would be available to many planners but would be managed on a corporate level to ensure accuracy and consistency. Additionally, new processes can be developed that can operate with the same stored data reducing the cost of progress (Date, 1990:16).

Improvement in this area was illustrated in the prototype through use of globally defined data that was available to all planners. Aircraft, airfield and customer unit characteristics are managed centrally and all planning uses the same data. Recent changes can be quickly advised to all planners through a note attached to global data. Further, operations specific data is still maintained in one central location, allowing executives and planners to view the overall ALG airlift effort.

Data Integrity and Collection

A corollary of corporate level data management is that data becomes more integrated and useful to the organisation. Individuals in the present system have their own files concerning an operation and the characteristics of airlift resources and payloads. Individuals must build and maintain their own knowledge base.

With reduced redundancy, a corporate RDBMS will remove inconsistencies in data and collect data once for all individuals (Date, 1990:15). Data accuracy will be improved as the most qualified personnel become responsible for collection and maintenance of components of the RDBMS, under the watchful management of an overall data manager. With proper management, all users can be confident that data is current and accurate, reducing the investigation phase of decision making.

Greater Portability of Data and Planning Activities

Presently, accurate planning can only occur in the presence of tasking boards and numerous files. Removal of files from the planning area increases likelihood of loss and restricts other planners from continuing with planning activities.

The RAPS corporate and electronic approach to maintenance of data allows planners to access data from remote sites. This removes the need for planners to be at ALG to be able to plan, improving ALG's flexibility to locate planners. For example, airlift between two remote airfields with dedicated airlift resources may be more effectively planned by having planners at one or both sites.

Portability of data is shown by the prototype. Not only are the prototype's memory and size demands easily met by many "lap-top" computers, simple communications tests showed that the system was easily accessed remotely.

Improved Security of Data and Communications

The centralised control of data provided by RAPS allows access to data to be controlled and allowable actions to data to be defined for each user (Date, 1990:16). In the prototype, access to the system is password controlled. Some transactions are restricted to the system manager or to users with specific job types. Further, airlift operations available to users can be defined by job type and by individuals.

By applying different access restrictions across the data base, RAPS applies sound security concepts. Only users with a genuine requirement have access and data is transparent to users that do not. Layers of access rights and restrictions on transactions available to classes of users further protect data and enforce restriction of access to classified data.

Further, centralised or reduced numbers of data sites allows more effective physical security to be applied at critical sites. Measures include fireproof safes and implementation of consistent and extensive

back-up procedures. Presently, data is held by individuals who apply varying physical security measures. All ALG airlift planning working data is held in hard copy form in one building. While this makes entry security easier to enforce, significant and protracted disruption of airlift services would result in event of fire or other natural disaster.

Another source of data insecurity is in communications. Users are often tempted to compromise data security requirements because present transmission means, such as safe hand mail, do not meet distribution time restrictions. Planners saw secure and timely connection to outside agencies as a major deficiency in the present approach (Peak, 1991a:2 July; Small, 1991).

Defining and providing users with secure means of electronic data communications, through DISCON, allows planners to meet time deadlines without compromising data security. Additionally, a standardised approach to data transmission can be adopted for all operations based on the highest required security level, thus improving consistency of interface to ALG and external agencies.

Faster Communication of Airlift Planning and Changes

During Exercise Kangaroo '89, problems were experienced with the timely distribution of air mode instructions. Development of the RAPS communications suites will allow faster communication of airlift planning and changes to customers and mode operator components. By decreasing the time to solicit and distribute information, airlift can become more responsive.

Initial evolutions of design may simply use facsimile transmissions over secure means in the interests of risk minimisation

and early delivery of benefit to users. Even this level of sophistication will improve timeliness of transmissions as RAPS would be able to automatically format, address and transmit data to each agency. Later evolutions towards a distributed network will further improve the speed, flexibility and reliability of airlift system communications.

Establishment of a Standardised and Logical Data Flow

Presently, no standard ways to plan airlift or present airlift flows exist in ALG. This causes inconsistencies as approach is based on who is performing planning or the parent service of the customer units. A consistent approach is desired (Mitchell, 1991).

With centralised control of data, standards can be enforced in the representation of data. Use of a proven and documented airlift planning approach that can be enforced through control of data allows airlift planners to apply a consistent management approach (Date, 1990:16). Additionally, a clear defined approach allows better documentation of procedures and responsibilities.

Through a standard well-documented approach to operational airlift planning, reductions in learning time for new planners and improved flexibility in employment of personnel are available. As well as aiding data sharing between airlift operations, standards allow ALG and external agencies to better understand procedures for interfacing with airlift planners and information that is presented to them by ALG.

For example, the prototype supports mission planning by recording flight times and likely wind effects during an operation. Presently, each planner derives their own mission planning mix of flight times, distances and wind effects. Under RAPS, all planners will be supported by consistent data that has been validated previously.

Improved Load Estimation

Development of a model to assist estimation of loads offers advantages in sophistication of estimation techniques and speed, magnifying capabilities of skilled planners. To inexperienced planners, models provide reasonable initial solutions where currently no assistance occurs.

The value of a model increases with its standard use. Through standardisation, model performance with different airlift scenarios can be reviewed and improved, embarking the load estimation function on a course of continual improvement.

Improved communications and electronic maintenance improves the potential for ALG agencies to provide detailed documentation in support of load estimates. Flying squadrons can be quickly appraised of expected loads and their recommendations used to improve estimations. Air terminals can provide a similar service.

Presently, planners estimate load requirements over a period or for a unit based on little data and no communication with units concerned. Yet, the viability of further planning largely depends on accuracy of estimates. Even from the earliest increments of RAPS, greater involvement of air terminals will be used to validate load estimates prior to mission tasking.

Under RAPS, planners will still estimate loads for units, time periods or departures or destinations. But, they will be assisted by a decision support component that will relieve them of the numerous calculations required, allow sensitivity analysis of different modal selections and provide ready transfer of results to later planning activities. Already, the prototype offers this service.

Additionally, planners will be able to have these estimates quickly and accurately justified by air terminals. Invalid estimates will be promptly recognised and remedial action taken before possible breakdown of airlift under way.

Improved Routing and Scheduling of Airlift

Similar advantages accrue from use of models to assist in aircraft flow scheduling. In load estimation the effect of poor decisions is not directly felt and can remain hidden from critical review. Aircraft scheduling decisions, however, directly affect aircraft tasking and poor decisions can be tracked to inefficient scheduling even at the planning stage. At the review stage, certainty of information and time make inefficient scheduling deceptively obvious.

Presently, during static flow planning, planners apply heuristics based on their own perceptions. ALG recognises that this leads to inconsistencies in approach and relies on planners having necessary skills (Newcombe, 1991:26 July). Time restrictions during airlift implementation force planners to avoid making non-essential changes to an airflow, even though improved efficiency may result. Not surprisingly, when surveyed, all planners called for some form of automated routing and scheduling support.

Development and improvement of a scheduling model to assist planners will improve scheduling on large airlift operations where flow complexity exceeds human capacity. Feasible flows will be derived sooner and routine flow calculations made by the system, freeing the planner for difficult flow decisions.

Greater sensitivity analysis will be provided due to the system's speed and flexibility where little is now performed because of time

frames available. Additionally, use of a standardised and tested routing and scheduling tool should reduce unnecessary and serious inefficiencies in airlift application and improve justification of decisions in the presence of uncertain information.

ADANS shows that it is possible to produce interactive software that greatly assists the planning of airlift. However, development of software to route and schedule all ADF airlift is not envisioned in initial increments because return on scheduling systems for aircraft such as the B707 and civil charter does not justify the extensive and risky development required. Yet, a model to assist most ADF scheduling has already been defined at Appendix H and software is expected in the first development evolution.

Improved Recognition and Resolution of Airlift Conflicts

Effectively, in the present system, each mission is planned in isolation from other missions pertaining to the operations and other ALG airlift undertakings. Airlift conflicts are resolved when planners locate the clash by chance or are advised by other ALG agencies. Consequently, conflicts are often resolved at the last minute causing inefficiencies in airlift use, inconvenience to planners and crews and problems with timely distribution of changes.

RAPS provides automatic checking of conflicts across all ALG operations providing quicker identification of conflicts and allowing more structured approaches to airlift conflict checking. Additionally, RAPS's flexibility of data presentation allows airlift to be grouped by different criteria. This improves visibility over airlift and recognition of potential conflict or bottlenecks. Examples of this

include the ability to isolate airflow through specific terminals, by aircraft types or pertaining to certain customers.

Improved Auditing of Actions

With the move to PMB, Government has dictated that managers will be accountable for effectiveness and efficiency of resource use. Just as importantly, government has decreed that managers must be able to demonstrate claims of efficiency and effectiveness (RFPD, 1990:1).

The present ALG approach does not provide for consistent and detailed recording of decisions. Review of past airlift showed little recording of actions or decision justification (Small, 1991; Newcombe, 1991:19 July). Many planners justified their actions with comments such as "the airlift requirement was met and that is the bottom line." In short, this approach will not sit well with PMB.

RAPS will improve justification and demonstration of effective and efficient resource use by ALG. Requirement and resource definitions and amendments will be recorded. Airlift operation state will be automatically recorded on a regular basis. Actual airlift results will be recorded against planned airlift.

This depth of automatic recording will not further burden airlift planners and its electronic form will allow efficient and effective review of actions. The merging of this data with shift logs will provide a complete cause and effect picture of airlift operations.

Additionally, RAPS will incorporate doctrine into processing structure. RAPS will enforce movements and mode operator doctrine by restricting transactions that do not accord with it, though user override of restrictions will be possible. Assuming that doctrine best

represents requirements of the ADF and the system represents doctrine, then the system will be proof of valid airlift planning approaches.

For example, doctrine dictates that all new lift requirements must be approved by the operation's mounting authority because it is better positioned to gauge relative priorities. Presently, pressure is placed upon planners to circumvent mounting authority approval of new lift in the interests of time. RAPS will allow for speedy electronic transmission of new requests and all requests will be screened for valid mounting authority approval. By configuring RAPS to automatically re-route all new requests to the responsible mounting authority, conformance with doctrine will be enforced transparently to planners and customers.

<u>Greater Review of Planned Airlift Against Actual Airlift</u>

RAPS incorporates review of actual performance into the airlift planning process. Actual airlift performance is solicited from ALG and external agencies and linked to planned airlift. During airlift implementation, this allows planners and executives to gauge flow state, requirements still not met and resources remaining uncommitted. Using actual airlift to derive airlift state provides planners with improved certainty of decision data.

Upon completion of airlift, RAPS provides review statistics concerning achievement and resource expenditure. This information is provided more quickly and accurately than the present approach because of difficulties in gathering reliable data (Peak, 1991a:2 July; Small, 1991).

Additionally, consistent statistics based on feedback are available to measure a standardised approach to airlift planning. This

allows ALG planners and executives to continually improve the airlift planning process.

Greater Involvement of ALG Agencies

Greater involvement of ALG terminal agencies in planning will improve accuracy of load estimation and smooth transition from planning to implementation activities. Being able to present planning to ALG agencies quickly but without additional work will encourage planners to present their planning for review. Presently, time usually forces them to rely on agency reaction to implementation tasking.

Improved Connectivity to External Agencies

Planners do not exist in isolation. Their tasks are determined by mounting authorities and decisions made are only useful if they are advised in sufficient time to be useful to customers and ALG agencies. The present system experiences severe limitations in the receipt and distribution of information concerning airlift. Problems are exacerbated by security restrictions on available transmission means.

RAPS provides more efficient access to dispersed players. RAPS provides planners with a secure transmission means and a system that can automatically format messages for dispatch. As time taken to advise decisions is reduced, airlift either becomes more responsive or planners are allowed more time to make decisions. While, insecure means are sometimes used presently because time restricts use of correct means, RAPS's use of secure transmission for mail or conversational type messages improves operational security.

Finally, under the present system, vertical command structures introduce long time delays between decisions and advice. This is recognised and many commanders allow their command chain to be

circumvented in interests of timeliness. Through quicker formating and transmission of information between agencies and use of reply, on-forward and broadcast mail facilities, higher command endorsement and on-forwarding of requests will be quicker, allowing doctrine to be observed.

Improved Executive Support

Presently, because airlift planners are often placed under immense pressure to meet time requirements, executives often must compromise their information needs because planners lack the time to provide it. Through automated support for structured and semi-structured decisions, planners will be better able to devote their time to more unstructured problems and the information needs of the executive. Further, the flexibility of data format allows executive information needs to be gathered more quickly and accurately and in the most suitable form for the executive.

While the prototype does not include a dedicated executive support system, it offers automatic summarising of airlift planned and under way. This data can quickly be ported into commercial spreadsheet applications, allowing professional and accurate graphical representation of effort and achievement.

Effect on Effectiveness and Efficiency of Airlift Planning

Investigation activities of this research found that airlift planners do not agree on much! However, regardless of country, background or approach, all agree that airlift is ultimately measured in terms of effectiveness first and efficiency second. This section

evaluates the combined impact of RAPS advantages on overall airlift planning effectiveness and efficiency.

More Effective Application of Airlift.

For planners, RAPS provides quicker advice of changes, performs structured tasks, assists in the making of semi-structured decisions, maintains data in related, accurate and shared formats, distributes airlift changes to agencies and records actual performance against that planned.

These activities allow planners more time to make unstructured decisions. Decisions are improved through access to more certain, consistent and useful data, generation of initial solutions, improved sensitivity analysis and proofing decision impact. Decision approaches are also improved by review of planning against actual results.

By decreasing the cycle time of airlift planning decisions while improving their effectiveness, RAPS contributes to the overall effectiveness of operational airlift planning. Improvements in security of data and involvement of other agencies further contribute to improved effectiveness.

These improvements, plus a standardised airlift process that is known to mounting authorities and force commanders and actively solicits feedback on performance, must increase the image of ALG as an effective planner of airlift. Ten years ago, MAC embarked on a move towards increased automated support for airlift planning. Though difficulties were encountered, their image as effective airlift planners continues to grow and contributed largely to the freedom they were allowed in planning Desert Storm/Shield (Davis, C., 1991; Peterson, 1991; Fairlie, 1991).

More Efficient Application of Airlift

The present airlift planning approach relies on individual planners carefully considering available options and implementing the most efficient choice that is effective. Large airlift operation needs exceed the capabilities of individual planners but teamwork is difficult given the inability to effectively share data.

This was demonstrated during Exercise Kangaroo '89 where the author performed airlift planning. Despite the large size of airlift committed to the exercise and its importance to overall exercise aims, airlift planning was essentially vested in one person. Airlift was less efficient simply because time restricted investigation of decision alternatives. Though executive management recognised that effectively vesting all airlift planning responsibility in one person was dangerous, the existing system provided little alternative (Peak, 1991a:5 July).

Through availability of more accurate and timely information to multiple planners and consistency in approach, RAPS allows greater teamwork. This, combined with improved what-if analysis provided by RAPS models and the freeing of planner time from structured tasks, is expected to improve the range of options considered in meeting requirements. This should improve efficiency while not compromising effectiveness.

Summary

This chapter investigated proposed improvements that would result from a computer based MIS to assist airlift planning. A prototype was used to demonstrate increment one feasibility and demonstrate clear improvements available from increment one implementation. Eighteen

improvements offered by all increments of RAPS were then discussed, finishing with their overall impact on effectiveness and efficiency of RAAF operational airlift planning.

VII. Implementation Issues

Overview

Earlier chapters researched requirements, analysed systems and proposed a MIS based RAAF system to assist airlift planners. Chapter VI discussed the many advantages that the system offered. All advantages were based upon careful implementation of a system that minimised likelihood of wrong functionality, poor user support, unreliability and difficult maintainability.

This chapter discusses risk and change management issues that airlift planners will have to consider during implementation of RAPS.

Risk Management (Boehm, 1989:1,98-100)

As shown by Figure 7-1, Boehm considers risk management to have two aspects: risk assessment and risk control (Boehm, 1989:1). Risk assessment involves risk identification, risk analysis and risk prioritisation while risk control involves risk management planning, risk management execution and risk monitoring.

Risk identification produces lists of project specific items likely to compromise a successful development and uses techniques such as checklists, decomposition and comparison with experience. Risk analysis produces assessments of the likelihood and the severity of loss for each risk item identified and compound risk through item interaction. Network analysis, decision trees, cost models and performance models are typical tools of analysis.

Risk prioritisation orders risk items so that overall risk remains within acceptable bounds during development. Techniques range from

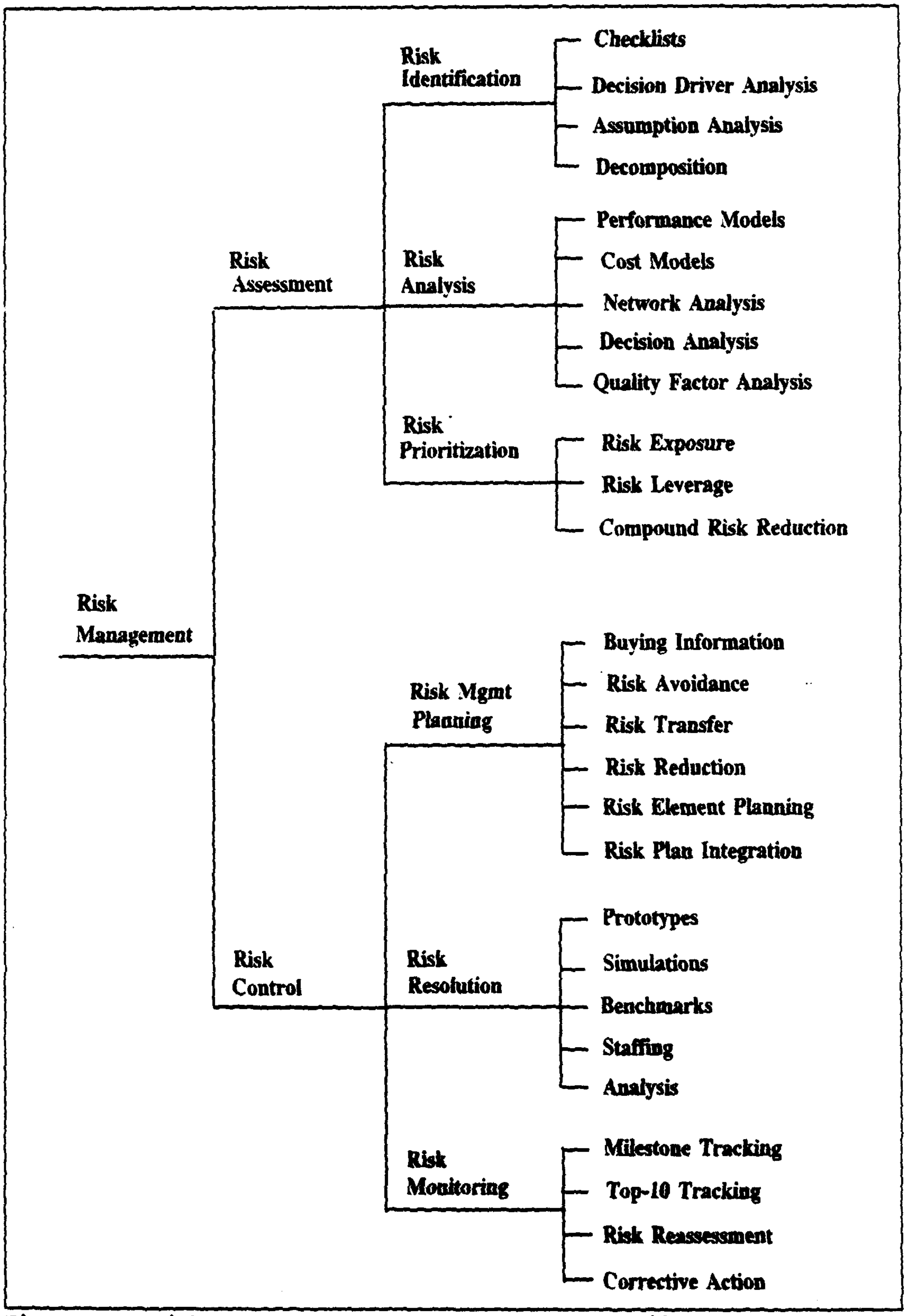

Figure 7-1. Risk Management Components (Boehm, 1989:ii).

quantitative analysis using prior probability theory to group consensus of opinion.

Risk management planning produces plans for addressing each risk item. Plans are coordinated with each other and the overall development. Where risk is unacceptable, risk resolution techniques are employed to eliminate or reduce likelihood of acceptable outcomes. Information can be bought through further testing, simulation or prototyping, or development transfered to later stages of the project, when more information will be available. Alternatively, skilled and proven personnel can be secured to control risky aspects.

Risk monitoring involves tracking the development's progress towards resolving risk items, through use of milestones and high risk item highlighting.

While each development has unique risk sources, Boehm identifies ten "top" items that generally introduce risk in software projects. He also provides risk management practises that address and resolve each. The risk items are:

1. Personnel shortfalls, which can be managed by staffing key areas with top talent, cross training and pre-scheduling key personnel.

2. Unrealistic schedules and budgets, which can be avoided through detailed and multi-sourced scheduling, incremental development, software reuse and dropping of high risk but marginal return requirements.

3. Developing the wrong software function, which can be avoided by thorough organisational and mission analysis, user surveys and prototyping.

4. Developing the wrong user interface, which can be addressed through prototyping and analysis of users' style, workload and functionality.

5. Gold plating. Unnecessary "bells and whistles" functions can be identified and dropped by cost-benefit analysis and adhering to firm cost limits.

6. Continuing stream of requirements changes. A problem with the evolutionary approach to development is that requirements can constantly change. The organisation never settles into new approaches which frustrates users and undermines improvements. This can be avoided by having firm increments of development and deferring last minute changes to later stages.

7. Shortfalls in externally furnished components and tasks performed. Reference checking and pre-audits should proceed contracts to companies for critical items. During development, bench marking, inspections and incentive contracts can improve likelihood of meeting requirements and time frames.

8 and 9. Performance shortfalls in delivered systems can be avoided through simulation, bench marking, modelling, prototyping and tuning.

10. Straining computer science capabilities. While attempting to design innovative systems, many past ADF software projects have been unsuccessful largely because they relied on a level of technology that was not proven. By analysis of technical capability, cost-benefit and prototyping, development at increments can be tied to dependable technology (Boehm, 1989:99).

Change Management

Risk management tries to develop the right product for the organisation. Successful automation of information management must also effectively manage organisational change to make the organisation right for the development.

The task of managing organisational change in large organisations like the RAAF is not easy. According to Nadler, employees must be motivated to perform during the change process and to simultaneously accept that the old ways of performing are no longer applicable (Nadler, 1989:495). Political behaviour usually becomes more apparent, adding to the difficult task of organisational change (Nadler, 1989:495).

According to Cummings and Hughes, there are five activities that contribute to successful organisational change. The first is motivating the change. In order to motivate the organisation to change the environment, an atmosphere of readiness to change must be nurtured.

Readiness to change involves three steps: sensitising the organisation to pressures to change, revealing discrepancies between the current and desired states, and conveying credible positive expectations for change. At the same time that the organisation is being readied to change, resistance to change must be overcome. One of three strategies can be used to overcome this resistance: empathy and support, communication, and participation and involvement (Cummings and Hughes, 1989:110-111).

The next activity that contributes to change is creating a vision of the future. This involves identifying broad parameters of change, while specific details are left to be worked out during implementation. Creating this vision is the job of the leadership of the organisation

and involves reinforcement of mission, valued outcomes, valued conditions, and midpoint goals (Cummings and Hughes, 1989:114-115).

Developing political support is the third step. Individuals must be sold the idea that the change will be better for them. In order to develop the necessary support, the change agent must assess his own sources of power, identify the key stakeholders, and influence those stakeholders (Cummings and Hughes, 1989:116-119).

Fourth, managing the transition, involves the period of time when the organisation is "between" states - that is, it has not fully given up the old way and is not fully committed to the new way of doing business. There are three major activities and structures that support organisational transition.

Activity planning involves laying out a road map for change, citing specific events that must occur if the transition is to be successful. Commitment planning involves identifying the key groups whose commitment is needed for change and deciding how to gain their support. Management structure must be adapted in order to include those people that have the power to mobilise the necessary resources to promote change (Cummings and Hughes, 1989:120).

Lastly, once the change process has begun, management attention must be focused on how to best sustain the energy and commitment to fully implement the change. There is a strong tendency for an organisation to return to the old way of doing things if the new way is not reinforced (Cummings and Hughes, 1989:121).

The process involves providing the proper resources for change, building a support system for change agents, developing the required

competencies and skills, and reinforcing desired new behaviours (Cummings and Hughes, 1989:121-122).

By treating the change as a complete and thought out process, its management becomes easier. Change must be dealt with in a logical and systematic approach, while at the same time providing the personnel associated with the change the correct amount of concern and compassion as they go through the change process.

Summary

The proposed computer based MIS to assist RAAF planning has potential to improve effectiveness and efficiency of RAAF airlift planning. However, to achieve this potential, its introduction must be carefully managed. The right product has to be delivered to users and this can be achieved by risk management. Additionally, target organisations, principally ALG, have to be made right for change, which can be achieved by change management.

VIII. Conclusions and Recommendations

Overview

This chapter contains the conclusions reached in meeting the objectives of this research and offers recommendations for further research in the area of computer based systems to assist airlift planning.

Conclusions

Increasingly, ADF managers are being challenged to demonstrate the effectiveness and efficiency of their systems. This research investigated improving RAAF strategic airlift planning by use of a MIS.

Airlift is at the heart of Australia's defence-in-depth strategy as it provides the essential mobility to project military power from remote areas. ADF airlift is managed by RAAF's ALG.

Airlift planning involves four interactive activities. During the first, activity planners investigate an operation's likely airlift need by estimating resource capabilities and requirements. With more information, detailed static planning can be performed and the airlift schedule derived. Upon implementation, the airlift flow must be dynamically managed to react to changes in the operation's environment. With the airlift under way, planners measure actual performance against planning and adjust airlift to meet overall operation objectives. Measurement continues after the airlift has finished with review of procedures and performance.

Computer-based solution approaches to unstructured airlift problems face difficulties with accurate and complete definition of the

airlift environment. Heuristic methods that constrain airlift problems or seek near-optimal solutions are the basis of most practical computer based models to assist airlift planning, particularity the routing and scheduling of aircraft missions.

The RAAF planning approach is manual and suffers deficiencies in poor data control, unnecessary repetition of structured tasks, lack of consistency in planning approach, lengthy learning time for new planners, distribution delays and lack of feedback of actual performance. Similar problems are encountered by the CNDF, which also uses a manual approach.

The USAF uses several computer based systems to assist their airlift planning, ADANS being their principal system. Recently implemented, it comprises extensive database, modelling and communications suites. Structured decision making and checking are performed automatically for planners. Though an excellent system to assist large scale airlift planning, ADANS is not justified for the ADF airlift planning because its level of sophistication is not warranted.

A MIS is proposed to assist RAAF strategic operational airlift planning. It was developed using an evolutionary approach that seeks early involvement and return of benefits to users while minimising risk. The system includes functions of control, dialogue, data, models and communications.

Though future user needs may change development direction, the initial development is expected to have six increments. The first builds a RDBMS and provides mission and payload editors and basic report functions. Next, models to assist airlift estimation and aircraft scheduling would be developed. With planning capability in place,

feedback of actual performance would be improved by an increment that addresses issues of audit and review. Development then seeks to increase the time available to planners by improving communication to ALG and ADF agencies. The last two increments address the needs of airlift executives and deliberate scenario planners. Figure 8-1 matches the full system functions against wider operation milestones.

The proposed system is expected to improve data management by reducing redundancy and collection needs while providing greater security, integrity, portability and data sharing among planners. Communication of airlift planning to outside agencies would be quicker and transition between planning and implementation smoother through improved access to ALG agencies. Models will assist with load estimation and scheduling, and should improve accuracy, timeliness and efficiency of results. Overall planning performance would be improved by improved feedback of actual airlift, statistical review of achievement and checking of decisions.

In all, significant improvements in effectiveness and efficiency of airlift planning are expected. However, these improvements will only be possible if the right system is implemented into the right organisation. This is possible through careful risk and change management during development.

Recommendations

This study recommends that the RAAF develop a MIS to assist the planning of operational strategic airlift. Development should be based on an evolutionary approach that delivers benefits to users quickly and

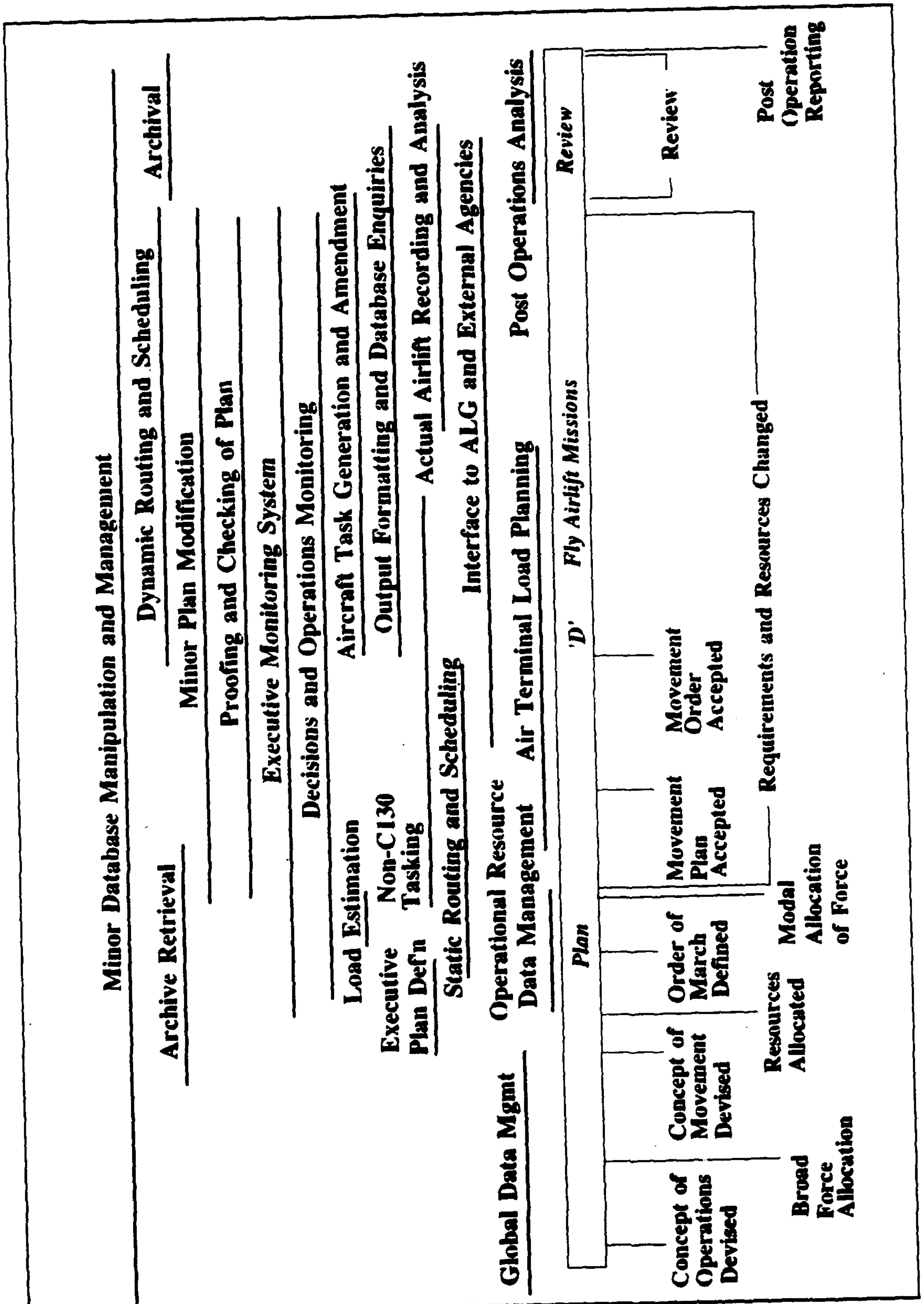

Figure 8-1. RAPS Functions Mapped to Wider Operation Milestones.

derives its development schedule from the changing needs of users while minimising risk.

Further Research

Further research is recommended in four areas: further system development, alignment of operational and non-operational airlift planning, alignment of tactical and strategic airlift planning, and generalisation of research findings to other military airlift planning systems.

Further System Development

The evolutionary development approach provides good scope for further research of computer based ways to assist RAAF airlift planning. Research of increment functions is required, especially in the later increments. Additionally, all models can be improved and greatest benefit would come from research to improve the computer based routing and scheduling system.

Alignment of Operational and Non-Operational Airlift

The intensity and destructiveness of modern warfare creates a punishing and uncertain environment for people and equipment through trauma and friction. Trauma or shock and physical damage, is characterised by death, organisational disruption, destruction of critical materiel and degraded communications. Recovery from trauma is complicated by the confusion and disorientation caused by the friction of war. Friction, the failure of events to follow plans, results from enemy integrity, organisational realignment, inadequate plans, wrongly positioned resources, poorly trained people, incorrect doctrine and

indecisive leadership occurring simultaneously (Department of the Air Force, 1986:3-3).

To withstand the combined effects of trauma and friction, a combat support structure must be capable of transitioning rapidly from peacetime to wartime and operating in a self-sustained, independent mode as it adjusts to combat. Airlift, a prime combat support function, must be supported by systems that provide for this rapid transition. Yet, the majority of airlift planning performed by the RAAF is in peacetime is non-operationally related.

An effective and feasible option available to the ADF lies in performing all strategic airlift activities the same way. By using the same system for both operational and non-operational airlift planning, RAAF airlift should be better prepared for the friction of wartime airlift. Training would be singularly directed and enhanced by regular application.

Further research is warranted into ways the RAAF to enhance the proposed system and change doctrine to align operational and non-operational airlift activities.

Alignment of Strategic and Within Theatre Airlift

Operational airlift is traditionally packaged into simple categories of strategic and tactical, or within theatre, airlift. Though "this view is logical, it is also myopic" (Cassidy, 1986:124). Airlift must be considered in terms of the resources that can be brought to bear to solve problems at hand. Airlift becomes a system of aircraft and other resources that can be used across the entire spectrum of conflict (Cassidy, 1986:124).

ADF strategic aircraft are earmarked to provide tactical support to operations and are removed from the strategic airlift resource pool. Assigning airlift resources solely to tactical airlift and managing their application using separate systems is likely to cause ineffective use of resources. Yet, although ADF doctrine recognises the scarcity of airlift resources and calls for airlift to be controlled at a high level, airlift management systems treat tactical airlift separately from strategic airlift.

Research is recommended into ways to incorporate operational strategic and tactical airlift planning systems to more effectively and efficiently apply scarce airlift resources.

Application to Other Defence Forces

This research showed that defence forces plan airlift in similar ways. Though the proposed system was designed for the ADF environment, it has potential applicability to other defence forces, especially those of similar size and structure to the ADF. Therefore, it is recommended that this research be generalised to other defence forces.

Closing Remarks

As the twenty-first century approaches, it is becoming increasingly clear how automated information can improve managerial efficiency. The need for this higher level of efficiency is demonstrated for the planning of operational strategic airlift. Often, airlift planners must assess their environments, allocate scarce resources and make numerous decisions virtually simultaneously.

There are limits to how fast even the most efficient planner can process and act on information assembled by conventional methods. As

this study has shown, automated technology can be developed to help planners make more, and theoretically better, decisions in the time constrained operational airlift planning environment.

Appendix A: Terminology

This appendix defines some of the terms and acronyms used within this study.

ADANS	USAF Airlift Deployment Analysis System.
ADF	Australian Defence Force.
ALG	Royal Australian Air Force, Air Lift Command.
CNDF/CF	Canadian National Defence Force or Canadian Forces.
Effectiveness	Ability to meet needs of a customer. Measures operational and surge capability of airlift resources.
Efficiency	Ratio of workload per airlift resource (productivity) to costs.
Evolutionary Development	Software development that has many stages of expanding increments of an operational software product, with the directions being determined by operational experience.
Heuristic	Approximate methods to obtain near-optimal solutions. A rule of thumb.
MAC	United States Air Force, Military Airlift Command.
Operational Airlift	The deployment, employment and sustainment of military forces through the medium of aerospace.
PMB	Program Management and Budgeting.
RAPS	Proposed RAAF Airlift Planning System.
RDBMS	Computer Relational Database Management System.

Risk	The possibility of some event occurring and the adverse consequence of that event should it occur.
Strategic Airlift	Airlift that transcends the boundary of any one theatre and is executed under central direction of higher authority, normally in support of a more pervasive or overall effort.

Appendix B: Survey of ADF Airlift Planners

This appendix contains the survey instrument which was sent to 29 ADF airlift planners, a summary of distribution statistics and a respondent profile. The instrument has been reduced and response boxes changed to meet layout requirements of this report.

Surveys were dispatched under cover of a letter explaining background to, and motivation for, the research. Each survey was tailored to the respondent, drawing sections from a master. Tailoring was based on the respondent's background and present location. The profile provides a summary of respondent's background, while the statistics show what parts of the master survey were sent to each respondent and distribution totals.

A Management Information System
To Assist Strategic Airlift Planning in the ADF

SURVEY of ADF PERSONNEL with experience in STRATEGIC AIRLIFT PLANNING

This survey investigates the planning of airlift. You have been chosen as a respondent because *of your experience* with ADF airlift planning. Information gathered from this survey will be used in the design of a management information system to assist planners of operational strategic airlift.

This survey forms part of research sponsored by the Director of Movements and Transport - Air Force. The research concerns **improving the quality and responsiveness of airlift planning.** It aims to automate simple tasks and assist an airlift planner in making less structured decisions. Issues of division of responsibilities or command and control are not addressed.

Survey Topics

This study **deals with the planning of operational strategic airlift.** Strategic airlift concerns the transport by air of personnel and stores to or from an Area of Operations (AO) or between AOs. Tactical airlift and routine, scheduled or channel airlift are not addressed. Operations include exercises, relief and disaster activities, peace-keeping efforts and operations in support of conflict.

There are eight topic areas. Those areas, and the number of questions presented within each category, are:

1) Stages of airlift planning, 2 questions;
2) The factors that contribute to a good airlift plan, 1 question;
3) Measurement of factors of good airlift, 18 questions;
4) Costing Airlift, 8 questions,
5) Information needs of a commander planning airlift, 7 questions;
6) Goals of an Airlift Planning Information System, 5 questions;
7) Requirements of component managers of the airlift system, 4 questions; and
8) General, 11 questions.

Response Technique

Three response styles are used in the survey: ranked, scaled and open-ended. The most common style requires a ranked response. A question is posed and a number of alternatives presented. You are asked to review the alternatives carefully and indicate your support for the option as an answer to the question. Your response in the form of a ranking should be placed in the box to the left of the question. A ranking of **1 indicates an answer you totally agree with. A higher ranking indicates a lessening level of confidence** in the response. A ranking over 10 indicates total disagreement with the answer. The same ranking can be applied to equal answers. You may apply a cross to an option that you consider is ominously wrong. Some responses require amplifying comment. Size of comment blocks are not meant to restrict your discussion, so feel free to attach extra comments if needed. You are also encouraged to comment on any question or option in the survey.

Scaled questions request indication of your degree of support to a statement. Please indicate your support by marking the appropriate part of the line to the left of the question. Open-ended questions request your comment.

Survey Return

The Deputy Director of Movements and Transport - Air Force, WGCDR Doug Peak, has offered to assist with questions concerning this survey and to receive responses. I ask your assistance to return this survey, in the accompanying envelope, to WGCDR Peak by **29 March 1991.**

Stages of Airlift Planning

This part of the survey deals with the stages of airlift planning. Two questions investigate the stages of airlift planning and their interrelation. Five stages are proposed;

F -> Formulation and acceptance of the general concepts of the plan.
D -> Detailed matching of uplift bill with airlift resources.
T -> Tasking of lift resources and warning of units to move.
M -> The implementation and maintenance of the plan.
P -> Post movement review of the plan.

Do you agree that there are five stages in airlift planning?

- [ ] Yes.
- [ ] Tasking and dissemination have nothing to do with planning.
- [ ] Implementation and maintenance have nothing to do with planning.
- [ ] There are more stages, such as ______
- [ ] A stage is not part of planning. Which stage? ______
- [ ] Tend to agree (Near enough anyway).
- [ ] Tend to agree though it varies from operation to operation.

How are the stages related?

- [ ] Stages are independent and follow sequentially.
- [ ] Stages are always dependent and iterative ie planning involves frequent visits to all stages and stage sequence depends on outcomes of stages.
- [ ] In small operations, stages are independent and sequential but in larger operations tend to become dependent and iterative.
- [ ] Stages are independent and sequential only in single service operations.
- [ ] Stages are independent and sequential only in single movement mode operations ie when only air is used to any scale.
- [ ] Stages are independent and sequential only in exercises.
- [ ] It varies from operation to operation.

Comments : ______

Factors that Contribute to a Good Airlift Plan

This part of the survey deals with identifying those factors which differentiate good airlift planning from bad. There is only one question. It is amongst the most important of the survey for no system can be improved unless its goals are clearly defined. 18 options are offered to answer the question. For each option, please indicate its degree of importance, if any, by applying a ranking. Rankings range from 1, indicating most important, through 10 for little importance. You may use a cross to indicate strong disagreement. You do not have to mark all options.

What do you look for in an airlift plan?

- [ ] Overall effectiveness in meeting aims of the customer.
- [ ] Productivity, by maximising quantities lifted.
- [ ] Economy, by committing lift resources in the most effective way.
- [ ] Efficiency or the highest ratio of productivity to costs.
- [ ] Simplicity, where complex tasking and routing are avoided.
- [ ] Training value to the airlift system.
- [ ] Fluidity or smoothness of lift ie avoiding tasking peaks and troughs.
- [ ] Cohesion or unity of lift of entities identified in the order of march.
- [ ] Flexibility or ability to absorb later changes.
- [ ] Certainty of meeting lift requirements in time.
- [ ] Accountability, where all decisions are justified and bounds observed.
- [ ] Control or ability to influence decisions made during implementation.
- [ ] Sensitivity, where alternatives and comparisons are provided.
- [ ] Format, where the plan can be quickly disseminated.
- [ ] Speed, where the plan has been quickly developed.
- [ ] Security and safety of airlift assets.
- [ ] Security of payload ie people and stores.
- [ ] Concentration or grouping lift effort to achieve most in short periods.
- [ ] Depends on the scenario and type of operation.

Comments: ____

____

____

____

____

____

Measurement of Performance

Having identified those factors which contribute to a good airlift plan, this part of the survey investigates their measurement. The aim is to find metrics to assist in determining planning performance. Metrics may be available during and after the planning process. Comparison of them with pre-defined or empirical values may assist in 'first cut' appraisal of a plan. There are 18 questions. A response to all is preferred. A cross can be used to highlight dangerous or ill-founded measurements. Comment is encouraged.

For each factor chosen as important, are there metrics that can measure performance of a plan within a category ie how do you judge the plan?

Overall effectiveness in meeting aims of the customer.

- [ ] Percentage of units lifted on their preferred day for airlift.
- [ ] Percentage of units lifted as an entity ie lifted together.
- [ ] Force capability delivered to ultimate AO destination per day.
- [ ] Percentage of units not delivered directly or transhipped.
- [ ] You cannot judge it up front. Those moved will tell you afterwards.

Other: ____

____

Productivity, by maximising lift resources.

- [ ] Tons/passengers carried one mile per flying hour, eg 1000 pax carried 1000 miles in 50 hours C130 = 20000 pax miles/hour C130.
- [ ] Tons/passengers per day lifted by priority designator.
- [ ] Order of march entities lifted per day, ie no. of distinct units.
- [ ] AO arrivals per day in tons and *passengers (Support area for return)*.
- [ ] Cannot be measured. It is an intuitive judgement.

Other: ____

____

Economy, by committing lift resources in the most effective way.

- [ ] Percentage of full aircraft loads planned to all loads planned.
- [ ] Hours aircraft flying without full payload.
- [ ] Hours aircraft flying without payload (ie deadheading or positioning).
- [ ] Percentage of chalks with more than one leg (multiple departure/dest).
- [ ] Total cost of plan, based on aircraft operating costs.

Other: ____

____

Efficiency or the highest ratio of productivity to costs.

- [ ] Payload moved per flying hour planned.
- [ ] Passengers and Cargo moved per flying hour, per aircraft type.
- [ ] Total payload lifted by number of miles moved, divided by cost of plan.
- [ ] Total hours aircraft are on ground, with no tasking, while away from Richmond ie hours airframe not used due crew rest or waiting.
- [ ] Force capability delivered to AO divided by total flying hours.

Other:____

____

Simplicity, where complex tasking and routing is avoided.

- [ ] Number of units lifted per chalk (average, maximum and minimum).
- [ ] Number of legs flown per chalk (average, maximum and minimum).
- [ ] Number of chalks per continuous airframe tasking (histogram form).
- [ ] Days airframes away from maintenance.
- [ ] The above except concentrating on most frequent and exceptions.

Other:____

____

Training value to the airlift system.

- [ ] Number of repeated legs (same departure and destination).
- [ ] Number of repeated legs per continuous airframe tasking.
- [ ] Flying hours per continuous airframe tasking (histogram form).
- [ ] Number of different types of loads planned (histogram form).
- [ ] Is not easily measured. Leave training to Airlift Group.

Other:____

____

Fluidity or smoothness of lift.

- [ ] Airframes committed per day (histogram form).
- [ ] Passenger/tonnage arrivals per day into AO (histogram form).
- [ ] Airframes uncommitted per day (histogram form).
- [ ] Hours flown per aircraft type per day (histogram form).
- [ ] Departures per day for all departure locations (3-D histogram form).

Other:____

____

Cohesion or unity of lift.

- [ ] Number of passengers transhipped (repositioned to a way point).
- [ ] Tons of cargo transhipped by priority.
- [ ] Number of order of march components not moved as one block.
- [ ] Number of times unit stores are not moved with unit.
- [ ] Number of times a unit is not lifted directly to desired destination.

Other:____________________________________

Flexibility or ability to absorb changes.

- [ ] Spare window per unit ie time planned to lift minus time must lift by.
- [ ] Spare window per unit ie time first available to move minus time planned to lift (Forward window availability).
- [ ] Payload capacity not yet committed, per departure location.
- [ ] Airframes uncommitted per day per aircraft type (histogram form).
- [ ] Hours uncommitted per aircraft type.

Other:____________________________________

Certainty of meeting lift requirements in time.

- [ ] Airframes uncommitted, per day ie max allowed minus no. committed.
- [ ] Hours uncommitted, per aircraft type ie max minus cumulative to date.
- [ ] Closure date minus last arrival/ first arrival/ all advance/ all main.
- [ ] First move allowed minus first move/ all advance/ all main.
- [ ] Days airframes have been away from maintenance venue, per day, per type.

Other:____________________________________

Accountability, where all decisions are justified and bounds observed.

- [ ] Full movement appreciation provided and all options enumerated.
- [ ] Same measures as economy.
- [ ] Same measures as efficiency.
- [ ] Not a factor in a good plan, just a part of staff work.
- [ ] Giving commanders dollars to buy military and civil lift (not hours).

Other:____________________________________

Control or ability to influence decisions made during implementation.

- ___ Days continuous tasking that must be committed per day.
- ___ Spread of airlift committed to units per day (histogram form).
- ___ Requirement for slip crews, maintenance away from home and crew changes.
- ___ Options possible during implementation (eg a decision tree).

Other: ______________________________

____

____

Sensitivity, where alternatives and comparative costs are provided.

- ___ Full movement appreciation and enumeration of alternatives.
- ___ Cost for each additional hour of airlift employed by type.
- ___ Hours available per aircraft type and cost comparison of types.
- ___ Chalk cost if met by military versus cheapest civil option.
- ___ Cost comparisons with previous similar airlift operations.

Other: ______________________________

____

____

Format, where the plan is in a form to allow immediate dissemination.

- ___ Hours required to produce an airlift schedule.
- ___ Hours required to produce a movement order and schedule.
- ___ Hours required for full plan dissemination.
- ___ Hours required to produce the fully detailed airlift schedule.
- ___ Hours required to produce schedules of different format for 'what-ifs'.

Other: ______________________________

____

Speed, where the plan has been quickly developed.

- ___ Same as format.
- ___ Hours taken to derive plan.
- ___ Similarity of plan to a contingency plan.

Other: ______________________________

____

Security and safety of airlift assets.

- [ ] Crew days over 10 hours (histogram form).
- [ ] Nights airframe parked away from a RAAF airfield.
- [ ] Rotations at low quality airfields ie dirt, short or narrow.
- [ ] Hours flown with augmented or slip crews.
- [ ] Hours flown over water.

Other:____

____

Security of payload ie people and stores.

____ Late afternoon arrivals of passengers in forward AO.

____ Arrivals of passengers without vehicles and stores.

____ Night time arrivals of payload.

____ Arrivals to and departures from civil controlled airfields.

____ Not an issue.

Other:____

____

Concentration or grouping lift effort to achieve most in short periods.

____ Most payload lifted in one day/ week (histogram form).

____ Percentage of order of march met in 24 / 48 / 72 /168 hours.

____ Days where full airframe allocation is committed (histogram form).

____ Main departure locations with spare ramp capacity yet outstanding bill.

____ Points of Entry and Departure supported.

Other:____

____

Costing Airlift

Dollar cost is often suggested as the primary metric for measuring all facets of airlift, including planning. Costing schemes often espouse a user pays concept to ensure ultimate control over airlift decisions rests with the user. This part of the survey investigates costing. There are eight questions. Five questions are open ended. Feel free to comment on viability of alternatives or problems concerning availability of data, commercial in confidence caveats or the breakdown of cost into direct, indirect or other components.

In costing airlift, what cost approach would best apply?

____ The Department's published hourly rate for ADF aircraft.

____ The contracted lease rate for commercial aircraft. Being actual, the calculated costs could be used to ensure budget compliance.

____ Rates for all airframe types set by the commander. That way, he could influence planning decisions by varying hourly costs. Additionally, mixing of civil and military 'costs' is allowed.

____ Hourly costs for civil aircraft would be actual lease costs. A rate per military airframe type would be set by the commander. That way, a commander could influence planning decisions and costings will reflect actual direct civil costs.

____ A proportional preference weighting of all aircraft types eg C130=2, B707=4, B767=10 therefore C130 twice as cheap per hour as B707 and five times cheaper than B767.

A different approach/ comments ____________________

____

____

____

How do you incorporate civil seat purchasing into a costing system? (The ADF uses civil airlift in two ways - it leases the whole aircraft or buys seats on commercial routes)

____ Use actual costs for all costing. Therefore, decisions will be based on the most economical decision.

____ Civil airlift is usually pre-planned at a high level. It is then presented to airlift planners as a fait accompli. Therefore, the airlift planner should concentrate on costing military airlift alone.

____ Use of seats on commercial routes is too small an aspect of airlift planning to concern a commander or his planning staff.

A different approach/ comments ____________________

____

____

____

How do you equate civil and military costing systems?

- [ ] Civil and military costing cannot be compared. There is no need to compare them as they apply to different situations.
- [ ] Civil and military costing cannot be compared. Yet, there is a need to compare them as they are usually viable alternatives when planning airlift.
- [ ] Civil airlift is usually pre-planned at a high level. It is then presented to airlift planners as a fait accompli. Therefore, the airlift planner should concentrate on costing military airlift alone.

A different approach/ comments ______________________________

____

____

Should the customer pay? Having the customer pay may be as simple as giving commanders 'chips' and charging 'chips' for airlift requested by the commander.

____

____

____

At the end of the planning process, does a commander wish to know the dollar cost of a plan? Should he and his staff be prepared to account for their decisions on economic grounds?

____

____

____

If so, can an accurate figure ever be provided at the planning stage?

____

____

____

At the end of the operation, does a Commander wish to know the dollar cost of a plan?

____

____

____

If so, can an accurate figure ever be provided at completion of all airlift?

____

____

____

The Information Requirements of a Commander of an Airlift Operation

This part of the survey addresses the information needs of the executive decision maker. The 'executive' level of airlift planning includes overall control and responsibility for an airlift operation. It may or may not include responsibility for airlift plan implementation or operation of aircraft. This section has seven questions requiring ranked responses.

How do the information needs of a commander initiating an airlift plan relate to the data maintained at the airlift planning level?

- ___ All of a commander's information needs are available from his airlift planning staff.
- ___ All of a commander's airlift information needs are available from his airlift planning staff.
- ___ Part of a commander's airlift information needs are available from his airlift planning staff.
- ___ A commander's information needs are not related to the information processing of the planning functions.
- ___ A commander's information needs determine the data maintained at the processing level. Therefore, one complements the other.

How do the information needs of a commander overseeing implementation of an airlift plan relate to the data maintained at the airlift planning level?

- ___ All of a commander's information needs are available from his airlift planning staff.
- ___ All of a commander's airlift information needs are available from his airlift planning staff.
- ___ Part of a commander's airlift information needs are available from his airlift planning staff.
- ___ A commander's information needs are not related to the information processing of the planning functions.
- ___ A commander's information needs determine the data maintained at the processing level. Therefore one compliments the other.

What is the most helpful form of information presentation to a commander?

- ___ Graphics only.
- ___ Graphics referring to detailed data concerning exceptions.
- ___ Detailed data only.
- ___ In electronic form.
- ___ In report form.
- ___ Able to be understood and used by the commander.
- ___ Able to understood and used by a commander's planning staff.
- ___ No information for the commander. Only that required by his staff.

With the present approach to airlift planning, is a commander provided with information of sufficient quality, in required time frames?

- [ ] Yes, there is ample information on which to make decisions.
- [ ] A commander doesn't need information. He needs people.
- [ ] No, the information is rarely complete.
- [ ] No, the information is there but rarely available in the time frame required to aid decision making.
- [ ] Yes, the information is there but not in the best format for presentation to executives.
- [ ] Yes, the information is there but not in the best format to manipulate for decision making.
- [ ] No, the data is there but it in not in a form useful to a commander.

If, for the previous question, you thought that information was not best for your requirements, why?

- [ ] Every commander's approach is different. Therefore no effective system can be implemented.
- [ ] External influences, such as scenario, time and politics, make each airlift operation different to all previous.
- [ ] The planners were too busy putting out bushfires and not looking at the requirements of the commander.
- [ ] The planners had the information, but not the technology to control and manage it.

Other: ____

____

To a commander making executive decisions on airlift planning, which of the follow would be helpful?

- [ ] A list of recent scenarios that have been tested or used in operations.
- [ ] The order of march for previous operations.
- [ ] Airlift summaries for previous operations.
- [ ] Airlift plans for previous operations.
- [ ] Actual lift data from previous operations.
- [ ] Airlift lessons learnt from previous operations.
- [ ] Nothing electronic - executive level planning is largely an intuitive function. No previous data helps. Just good people.
- [ ] Electronic presentation of all data. This allows speedy and accurate manipulation of data and quicker drafting of plans.

For past airlift summaries to be potentially helpful, what sort of data should they contain?

- [ ] Location of operation.
- [ ] A brief summary of the threat (maximum 200 words).
- [ ] Type of activity eg exercise/operation/relief/aid to civil.
- [ ] What ADF services were involved.
- [ ] What other forces or organisations were involved (friendly and enemy).
- [ ] Airfields used for strategic airlift within the area of operations, their actual frequency of use and operating restrictions.
- [ ] Services provided at airfields in area of operations or outside Australian mainland eg fuel, accommodation and security.
- [ ] Airlift planning bill in passengers, bulk cargo and wheeled cargo.
- [ ] Airlift maximum/minimum duration ie total and main component duration.
- [ ] Actual uplift in passengers, bulk cargo and wheeled cargo.
- [ ] Total hours and maximum per day allocated per airframe type.
- [ ] Actual number of airframes used per day (histogram form).
- [ ] Actual hours flown per aircraft type.
- [ ] Sorties lost or postponed due unserviceable aircraft.
- [ ] Comparison of planning and actual payload data.
- [ ] Airlift lessons learnt.

Other: ____

____

____

____

Management Information System Goals

This section considers what should be the goals of a management information system to assist airlift planning and the relative importance of potential sub-systems. There are five questions requiring ranked responses.

What should be the higher goals of a management information system to assist in airlift planning?

____ Audit or recording of system state and decisions.

____ Performance or maximum improvement.

____ Minimum or comparative cost including development and maintenance.

____ Reliability or accuracy and consistency of information and adequate and reliable system availability.

____ User satisfaction or acceptance by planners and executives.

____ Connectivity or ability to communicate with other systems and 'players' involved in movement of a force.

____ Maintainability or ability of the system to be kept running and for improvements to be easily made.

____ Control or ensuring users have control of deviations from planned performance and can institute corrective action.

____ Work capacity or ability to support development of multiple plans.

____ Usefulness or perceived ability of system to support organisational goals and objectives.

Other: ____________________

____

____

With what other information systems should communications be considered?
For each system nominated, please specify the level of connectivity from options of on-line or continuous connection, batch or periodic transfer and hardcopy transfer.

____	HQ ADF Command and control systems.	Online/Batch/Hard
____	Air Headquarters BACCS system.	Online/Batch/Hard
____	DMCA/ JMCC/ MCO systems.	Online/Batch/Hard
____	Aircraft maintenance control systems eg CAMM.	Online/Batch/Hard
____	Flying squadron tasking management systems.	Online/Batch/Hard
____	Scheduled airlift co-ordination systems.	Online/Batch/Hard
____	Other ____________________	Online/Batch/Hard

What capability or design aspects should the system have?

____ It should be portable so that planning can be carried out at the best location. Hence a PC based system is required.

____ A secure system due to the information held.

____ An interactive system ie not fully automated but reacts to commands from the planner.

____ A menu driven system that requires little training.

____ Data is held in a way that allows what-if analysis and special reports.

____ Maintains a history of previous exercises that can provide data.

____ Allows for quick input of the order of march and resource data.

____ All output can be represented on screen, on hard copy and graphically.

____ Other: ____

____

What capability or design aspects should the executive component of the system have?

____ It should be portable so a commander can take reports and displays with him when briefing or changing location. A PC based system is required.

____ Access to main system to allow a commander to look at all aspects of the plan and communicate his requirements to his staff.

____ Reliability. The system must always be available. All output must be accurate or limits of currency or accuracy obvious.

____ Ease of use. A menu driven system should allow maximum assistance to a commander with little training or computer skills.

____ Versatility. The system should present data so that a commander can manipulate and format it in ways that best suit him.

____ Exception reporting. A commander should be able to set limits or bounds on the detailed planning system. When planning exceeds these bounds, advice should be presented to the commander.

____ Hands off. All requirements of a commander should be part of a lower level system. His staff should present information to him.

____ Sensitivity analysis. The system should support what-if analysis at the executive level. Options specified by a commander should be modelled and outcomes presented in suitable form.

____ Remote communications. Facsimile transmission of unclassified data should be supported.

____ Other: ____

____

What sub-systems should the system possess? In this question, ranking also indicates your relative assessment of sub-system importance.

____ A static routing and scheduling system that automatically matches lift requirements with resources to produce a feasible plan. The system would require an order of march, a resource matrix and weighting.

____ A dynamic routing and scheduling system that would automatically apply changes to the environment to a plan. The original plan would be input.

____ A static routing and scheduling system that interactively matches lift requirements with resources to produce a feasible plan. The system and user would require an order of march and a resource matrix.

____ A dynamic routing and scheduling system that would interactively apply changes to the environment to a plan. The original plan would be input and the user would specify changes and direct plan manipulation.

____ A database to maintain the airlift plan and produce reports of varying format and criteria.

____ A graphical display and report capability ie charts and displays.

____ On-line electrical communications to other systems used to manage the movement and maintenance of a force.

____ Hardcopy reporting capability to all 'players' and connectivity to remote airlift components through encryption over public networks.

____ Maintenance of an 'audit trail' to allow analysis of performance and problems for post operation review. System should produce statistics.

____ Maintenance of history of airlift operations so new planning can draw on concepts and approaches where performance and problems are known.

____ A system to manage production and distribution of new or amended tasking and changes to a plan to all specified addressees.

Other:____

Interaction with Maintenance Components of Airlift

This section looks at how airlift planning impacts on managers of the component systems of airlift, principally the maintainers. There are two questions.

What factors of a plan impact on a maintenance manager? In addition to a ranking, please indicate like or dislike of the option.

_____ Late returning aircraft (like/dislike).

_____ Early departures (like/dislike).

_____ Special rigging requirements (like/dislike).

_____ All aspects of the B707. This aircraft requires special management.

_____ Maintenance requirements away from Richmond (like/dislike).

_____ Heavy tasking against one flying squadron (like/dislike).

_____ Tasking aircraft away for many days ie more than a week (like/dislike).

_____ Locating or resting aircraft away from Richmond (like/dislike).

_____ Long periods of consistent tasking (like/dislike).

_____ Long periods of excessive tasking (like/dislike).

_____ Short periods of excessive tasking (like/dislike).

_____ Planning down to each squadron and aircraft type (like/dislike).

_____ Sharing of similar tasking across squadrons (like/dislike).

_____ Considering maintenance requirements within the plan. This allows identification by maintenance with task objectives and makes administration of personnel attachments easier (like/dislike).

_____ Other: ____

____

How should the plan be presented to maintenance controllers?

_____ In 'green' order. Only formal squadron tasking and not planned tasking should be advised to the squadron.

_____ Tasking should be presented in electronic form for speed and efficiency.

_____ Tasking should be presented in hard copy form for ease of use.

_____ There should be one report provided at the start of the operation. Changes should be advised formally, with at least two days notice.

_____ There should be a report of *anticipated tasking* disseminated prior to implementation of the plan to allow squadron comment and preparation.

_____ There should be a weekly report of tasking only for the next week.

_____ A report is required for each aircraft type ie C130E, C130H, B707.

_____ Other: ____

Interaction with Air Movement Components of Airlift

This section looks at how airlift planning impacts on managers of the component systems of airlift, principally the terminal staff. There are seven questions.

What factors of a plan impact most on a terminal manager? In addition to a ranking, please indicate like or dislike of the option.

____ Late arrivals and departures (like/dislike).

____ Early arrivals and departures (like/dislike).

____ Special rigging requirements (like/dislike).

____ Mixing B707 and C130 tasking or mixing between C130 types.

____ Explosives loading/ unloading (like/dislike).

____ Heavy tasking in short time frames (like/dislike).

____ Basing an aircraft at major locations (like/dislike).

____ Taskings of similar loads eg freight chalks together (like/dislike).

____ Less than 1 hour turnarounds for quick loads (like/dislike).

____ Engines running turnarounds in forward locations (like/dislike).

____ Engines running turnarounds in support locations (like/dislike).

____ Other: ____

____

How should the plan be presented to load planners?

____ In 'green' order. Only formal aircraft tasking and not planned tasking should be advised to an air movement agency.

____ Tasking should be presented in electronic form for speed and efficiency.

____ Tasking should be presented in hard copy form for ease of use.

____ There should be one report provided at the start of the operation. Changes should be advised formally, with preferably two days notice.

____ There should be a report of anticipated tasking disseminated prior to implementation of the plan to allow AMS comment and preparation.

____ There should be a weekly report of tasking only for the next week.

____ A location's report should only have tasking effecting the location.

____ Other: ____

____

____

____

____

How should AMSs/MATUs interact with lift coordinators (usually MOVCORDC)?

- [ ] Planned loads should be advised to the AMS/MATU. At least two days before lift, AMS/MATU should advise actual load and spare capacity.
- [ ] The AMS should only talk to the MCO during the lift.
- [ ] The same system as routine lift should be used.
- [ ] After the lift has occurred, deviations from the planned task, including load, unit lifted and timing changes, should be advised to coordinators.
- [ ] AMSs/MATUs prefer planning to only scope short periods ie 3-5 days. Any more is usually inaccurate or subject to too much change.
- [ ] On-line/daily plan access is vital for AMSs/MATUs.
- [ ] Reports provided should allow AMSs/MATUs to access by Green No, by day, by dest/departure. Also a time spread of tasking should be provided.

How much flexibility should be given to terminals? Amount of flexibility can range from providing the terminal with three day windows of tasking and payload that it is free to match in any way it chooses, to providing the terminal with a firm load plan for each task. Comments based on experience are welcomed.

____

____

____

____

Should terminals be given more flexibility, what problems can you see for terminals, customers and MCOs eg non-advice of load changes which effect MHE and personnel requirements?

____

____

____

What is your opinion of a system where AMSs/MATUs would receive daily electronic updates of airlift plans? These updates would be transmitted electronically over secure or insecure means.

____

____

____

What is your opinion of a system where AMSs/MATUs are required to advise all task deviations to the coordinator? This information could be transmitted electronically or with aircraft returning to Richmond.

____

____

____

Interaction with Flying Squadron Components of Airlift

This section looks at how airlift planning impacts on managers of the component systems of airlift, principally the operators. There are two questions.

How should a plan be presented to a flying squadron?

____ In 'green' order. Only formal squadron tasking and not planned tasking should be advised to the squadron.

____ Tasking should presented in electronic form for speed and efficiency.

____ Tasking should be presented in hard copy form for ease of use.

____ There should be one report provided at the start of the operation. Changes should be advised formally, with at least two days notice.

____ There should be a report of anticipated tasking disseminated prior to implementation of the plan to allow squadron comment and preparation.

____ There should be a weekly report of tasking only for the next week.

____ Only squadron tasking should be advised.

____ All tasking, including that of other squadrons, should be advised.

____ Other: ____

____

What aspects of airlift planning does squadron management like or dislike? In addition to a ranking, please indicate like or dislike of the option.

____ Too many long crew days (like/dislike).

____ Many specialist crewing requirements eg night or short (like/dislike).

____ Tasking that takes crews away for overnights (like/dislike).

____ Continuous minimum crew rest after long tasking (like/dislike).

____ Days off away from Richmond for crew and airframe (like/dislike).

____ Augmented crews (like/dislike).

____ Slip crew requirements (like/dislike).

____ Long periods of consistent tasking (like/dislike).

____ Long periods of excessive tasking (like/dislike).

____ Short periods of excessive tasking (like/dislike).

____ Planning down to each squadron and aircraft type (like/dislike).

____ Sharing of similar tasking across squadrons (like/dislike).

____ Allocating all airlift in support of a sub-objective to one squadron. This allows identification of aircrew of task objectives (like/dislike).

____ Other: ____

____

Interaction with the Customer

This section of the survey looks at the interface between the customer to be lifted, the command coordinating the lift and the other movements organisations. There are two questions.

The primary statement of user need is the order of march. What information should be presented in the order of march to allow a full description of customer needs? A ranked response is requested.

____ Unit name.

____ Parent Command and coordinating movements control organisation.

____ Sub-unit name and party type eg 'B' Company/ Advance Party.

____ Numbers of passengers, bulk cargo, wheeled cargo. For bulk cargo, groupings by hazardous, outsize and restricted access categories.

____ Related order of march entries eg 15->5 may mean unit must follow entry 15 (HQ element) by up to 5 days.

____ Early or late move within window preference eg E/M/L.

____ Desired day to move eg D+10 or 15Jun or Friday.

____ Windows for movements ie time earliest available to latest move time.

____ Departure airfield.

____ Destination airfield.

____ Ultimate destination.

What aspects of airlift planning does a customer like or dislike? In addition to a ranking, please indicate like or dislike of the option.

____ Early starts (like/dislike and time period considered).

____ Late starts (like/dislike and time period considered).

____ Being lifted without unit stores (like/dislike).

____ Overnighting not at the destination (like/dislike).

____ Richmond - all aspects (like/dislike).

____ All passenger C130 loads (like/dislike) How many is max?

____ B707 or civil lifts with dress requirements (like/dislike).

____ Travel with other units (like/dislike).

____ Uplift over a long period (like/dislike).

____ Uplift over a short period (like/dislike).

____ Being planned down to sub-unit level (like/dislike).

____ A fixed time between advance, main and rear parties (like/dislike).

Other: ____

____

General Questions

This section of the survey proposes general questions. It seeks an indication of whether you agree or disagree with the statement. There are 11 questions.

Does the movement bill remain constant during planning?

____

____

____

If not, do certain components change more often than others?

____

____

____

Does the resource allocation remain constant during planning?

____

____

____

If not, do certain components change more often than others?

____

____

____

What reaction time is expected from planners after initial implementation of a plan?

Minutes Hours Days It varies

Do you have trouble meeting time frames? Could you use an information system that helps you calculate options, amends a plan to your specification and checks your actions?

____

____

____

How many large exercises do you have contact with each year?

0 1 2 3 4 5 6 7 8 9 10 more than 10

How many medium sized exercises do you have contact with each year?

0 1 2 3 4 5 6 7 8 9 10 more than 10

How many small exercises do you have contact with each year?

0 2 4 6 8 10 12 14 16 18 20 more than 20

How you ever consulted past exercises to assist in planning a new operation or exercise? What size exercises were involved? Was the old data helpful?

____

____

____

____

____

____

What is your opinion of the development of an airlift planning management information system?

_____ A system is not required or justified.

_____ Potential exists for a system but not right now.

_____ A system may be justified. However, the environment and hence the needs of the airlift planner are changing so quickly that a system would not keep pace with requirements.

_____ A system is justified. A complete analysis and development should be commenced so that a full and sophisticated system is developed the first time.

_____ A system is justified. However, the money and other resources required for a full system are not available right now. Finance approval procedures suggest development in two or three phases.

_____ A system is justified. We have the hardware. Planners can develop a system as part of the job.

_____ A system is justified. Because of the changing environment, full up-front development risks delivering an unsuitable and costly system. We should use an evolutionary approach where we develop those sub-systems that give us most value now. Gradually, these sub-systems will link to form a system that users require. This approach will allow resources to be applied in increments and their return immediate. Even if the final result is not perfect, we have better information with which to plan a replacement.

Other: ____

____

____

____

A Management Information System to Assist RAAF Airlift Planning
Survey Statistics

Topic Area ->		1 STAGES	2 FACTORS	3 WAYS TO	MEASURE				4 COSTING	AIRLIFT	5 COMMANDER	INFORMATION	NEEDS	6 SYSTEM	COMPONENTS	CAPABILITY	7 MAINTE'CE	8 AIRCREW	9 CUSTOMER	10 TERMINAL	OPERATORS	11 GENERAL	TOPICS
Questions: Ranked		2	1	18					5		5			5			2	2	2	3		5	
Open		0	0	0					3		3			0			0	0	0	4		6	
Total		2	1	18					8		8			5			2	2	2	7		11	
Pg->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	18	19	20	21
MAJGEN Sanderson	a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						1	1
ACDRE Mitchell	b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1				1	1
GPCAPT Harris	a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						1	1
Miller	d	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1
WGCDR Crombie	d	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1
Peak	e	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hartig	f	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1
Ryan	g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1	1	1
Shepard	g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1	1	1
Dunbar	h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1				1	1
Thyer	f	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1
Pryke	h	1	1	1	1	1	1	1									1						
Mayhew	i	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					
Scott	n	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1			1	1
Frame	h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1				1	1
SQNLDR Pottinger	d	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1
Mannen	d	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1
Hales	d	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1
Bradford	d	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1
Nattrass	k	1	1	1	1	1	1	1			1	1	1	1	1	1		1				1	1
Stanhope	l	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1	1	1	1	1
Green	e	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MAJ Thompson	e	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FLTLT Ross	m		1	1	1	1	1	1						1	1	1			1	1	1	1	1
Shields	m		1	1	1	1	1	1						1	1	1			1	1	1	1	1
Smith	m		1	1	1	1	1	1						1	1	1			1	1	1	1	1
Newcombe	m		1	1	1	1	1	1						1	1	1			1	1	1	1	1
WOFF McMullen	m		1	1	1	1	1	1						1	1	1			1	1	1	1	1
FSGT Small	m		1	1	1	1	1	1						1	1	1			1	1	1	1	1
Total Pages		23	29	29	29	29	29	29	22	22	23	22	22	28	28	28	7	13	17	18	18	27	27

548 Pages Total (pg1 refers to cover sheet type)
29 Total respondents
66 Maximum questions per survey
1914 Total questions

Survey Respondent Profile

Respondent	Background
MAJGEN Sanderson	Force Commander, HQADF planner
ACDRE Mitchell	Commander ALG, CMDRALG during Ex K89
GPCAPT Harris	OC86WG. Airlift command for Exercise K89
Miller	HQADF movements planner, DG Movement and Trans-RAAF
WGCDR Crombie	HQADF movements planner for Exercise K89
Peak	HQADF planner, CO MOVCORDC, Airlift planner Ex K89
Hartig	SOPLANS ALG (Responsible for airlift)
Ryan	CO MOVCORDC, airlift payload coordinator
Shepard	Terminal operator
Dunbar	SOPOL ALG (ALG policy), CO 36SQN (Flying Squadron)
Thyer	SOPLANS ALG (Responsible for K89 airlift), CO 36SQN
Pryke	CO 486SQN (Intermediate Maintenance Squadron)
Mayhew	HQADF planner, CO 37SQN (Flying Squadron)
Scott	AirHQ planner, SOPOL Air Lift Group
Frame	HQADF planner, XO 36SQN (Flying Squadron)
SQNLDR Pottinger	HQADF movements planner, Terminal operator
Mannen	AirHQ movements planner
Hales	AirHQ movements planner
Bradford	ALG payload coordinator, Terminal operator
Nattrass	ALG task planner
Stanhope	Terminal operator
Green	OIC MATU, Terminal operator, Airlift planner
MAJ Thompson	Customer representitive to ALG, Airlift planner
FLTLT Ross	Terminal operator
Shields	Terminal operator
Smith	Terminal operator
Newcombe	OIC MATU, Airlift planner, Terminal operator
WOFF McMullen	Loadmaster, Airlift planner, Payload coordinator
FSGT Small	Airlift planner, Payload coordinator

29 Total respondents

Appendix C: Results of a Survey on Factors of Airlift Planning and Their Measurement

This appendix provides results to survey questions that considered the factors of airlift planning and their measurement. Eighteen factors were presented to respondents for evaluation.

A factor's value to planning performance could be principal, important, contributing, unimportant or unrelated based on respondents scores which ranged between one and ten. A principal value occurred when a one score was judged by respondents. Where a factor received a rating between two and four, it was considered important. A rating between five and eight earned the factor a contributing value, while scores above this caused the factor to be rated as unrelated. Where no score was given, no measure of value was judged.

Regardless of their views, planners were invited to identify metrics to measure each factors. If respondents considered the proposed option to be a suitable metric for the factor, a one was recorded.

The last page of this appendix, C-20, provides a summary of respondent appraisals across all factors.

Airlift Planning Measure Response Summary

Measure: Overall Effectiveness

	Value of Measure: PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	Suitable Metric: 1	2	3	4	5
ACDRE Mitchell	1					1				
GPCAPT Harris	1					1	1	1		
Miller		1							1	
WGCDR Peak					1					
Thyer	1					1	1	1	1	
Pryke	1					1	1	1		
Frame	1					1	1		1	
SQNLDR Pottinger	1					1	1	1	1	
Bradford	1					1				
Nattrass	1					1		1	1	
Green	1					1				
MAJ Thompson	1					1	1	1	1	
FLTLT Ross	1					1	1	1	1	
Smith		1				1	1	1	1	
Newcombe	1					1	1	1		
FSGT Small	1					1				
Count	13	2	0	0	1	14	9	9	8	0
Percent	81.3	12.5	0	0	6.25	88	56	56	50	0

Airlift Planning Measure Response Summary

Measure	Productivity									
	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1		1	1	1	
GPCAPT Harris		1								
Miller		1						1		
WGCDR Peak		1								
Thyer		1					1	1	1	
Pryke		1					1	1	1	
Frame		1				1	1	1	1	
SQNLDR Pottinger		1				1	1	1	1	
Bradford	1								1	
Nattrass			1						1	1
Green		1				1	1			
MAJ Thompson	1						1	1	1	
FLTLT Ross		1					1	1	1	
Smith					1	1	1	1	1	
Newcombe		1						1	1	
FSGT Small	1					1			1	
Count	3	10	1	0	2	5	9	10	12	1
Percent	18.8	62.5	6.25	0	12.5	31	56	63	75	6.3

Airlift Planning Measure Response Summary

Measure   Productivity

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1		1	1	1	
GPCAPT Harris		1								
Miller		1						1		
WGCDR Peak		1								
Thyer		1					1	1	1	
Pryke		1					1	1	1	
Frame		1				1	1	1	1	
SQNLDR Pottinger		1				1	1	1	1	
Bradford	1								1	
Nattrass			1						1	1
Green		1				1	1			
MAJ Thompson	1						1	1	1	
FLTLT Ross		1					1	1	1	
Smith					1	1	1	1	1	
Newcombe		1						1	1	
FSGT Small	1					1			1	
Count	3	10	1	0	2	5	9	10	12	1
Percent	18.8	62.5	6.25	0	12.5	31	56	63	75	6.3

Airlift Planning Measure Response Summary

Measure — Economy

Measure	Value of Measure: PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	Suitable Metric: 1	2	3	4	5
ACDRE Mitchell					1					1
GPCAPT Harris	1									
Miller		1				1				
WGCDR Peak		1				1				
Thyer	1					1	1	1	1	1
Pryke	1					1	1	1	1	
Frame	1					1	1	1	1	1
SQNLDR Pottinger		1				1	1	1	1	
Bradford		1				1				
Nattrass		1				1		1		
Green	1						1			1
MAJ Thompson	1					1	1	1	1	
FLTLT Ross		1				1	1	1	1	1
Smith			1			1	1	1	1	1
Newcombe		1				1	1	1	1	
FSGT Small		1				1				
Count	6	8	1	0	1	13	9	9	8	6
Percent	37.5	50	6.25	0	6.25	81	56	56	50	38

Airlift Planning Measure Response Summary

Measure **Efficiency**

Measure	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1					1
GPCAPT Harris		1								
Miller		1								1
WGCDR Peak		1				1	1	1	1	1
Thyer		1				1	1	1		1
Pryke		1				1	1	1	1	1
Frame		1				1	1	1	1	
SQNLDR Pottinger		1				1	1		1	1
Bradford			1				1			
Nattrass		1						1		1
Green		1						1		
MAJ Thompson		1				1	1		1	1
FLTLT Ross		1				1	1	1	1	1
Smith		1				1	1	1	1	1
Newcombe		1				1	1	1	1	1
FSGT Small				1		1	1			
Count	0	13	1	1	1	10	11	9	8	11
Percent	0	81.3	6.25	6.25	6.25	63	69	56	50	69

Airlift Planning Measure Response Summary

Measure — **Simplicity**

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell		1						1		
GPCAPT Harris		1								
Miller		1								1
WGCDR Peak					1	1	1	1	1	1
Thyer			1			1	1	1		
Pryke		1				1	1	1	1	1
Frame		1				1	1	1	1	
SQNLDR Pottinger		1				1	1	1	1	
Bradford		1					1			
Nattrass		1								1
Green		1						1		
MAJ Thompson	1					1	1	1	1	
FLTLT Ross		1				1	1	1	1	1
Smith					1	1	1	1	1	
Newcombe		1				1	1	1		1
FSGT Small		1					1			
Count	1	12	1	0	2	9	11	11	7	6
Percent	6.25	75	6.25	0	12.5	56	69	69	44	38

Airlift Planning Measure Response Summary

Measure	Training Value									
	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1					1
GPCAPT Harris		1								
Miller			1							
WGCDR Peak					1					
Thyer			1			1	1	1	1	
Pryke		1								
Frame			1					1	1	
SQNLDR Pottinger			1					1	1	
Bradford			1							1
Nattrass		1								1
Green			1						1	
MAJ Thompson		1							1	
FLTLT Ross			1							
Smith					1	1	1	1	1	
Newcombe		1					1	1	1	
FSGT Small			1							1
Count	0	5	8	0	3	2	3	5	7	4
Percent	0	31.3	50	0	18.8	13	19	31	44	25

Airlift Planning Measure Response Summary

Measure **Fluidity**

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell	1					1				
GPCAPT Harris		1				1				
Miller			1				1			
WGCDR Peak		1							1	
Thyer		1				1	1	1	1	1
Pryke		1				1	1	1	1	1
Frame		1				1	1	1	1	
SQNLDR Pottinger		1				1	1	1	1	1
Bradford		1				1			1	
Nattrass		1				1	1			1
Green		1					1		1	1
MAJ Thompson		1				1			1	
FLTLT Ross		1								
Smith					1	1	1	1	1	1
Newcombe		1				1	1	1	1	1
FSGT Small		1				1			1	
Count	1	13	1	0	1	12	9	6	11	7
Percent	6.25	81.3	6.25	0	6.25	75	56	38	69	44

Airlift Planning Measure Response Summary

Measure | Cohesion

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell		1						1	1	1
GPCAPT Harris		1								1
Miller		1							1	
WGCDR Peak		1								1
Thyer	1					1	1	1	1	1
Pryke		1				1	1	1	1	1
Frame		1				1	1	1	1	1
SQNLDR Pottinger		1				1	1	1	1	1
Bradford		1							1	
Nattrass		1						1	1	
Green		1				1	1	1	1	1
MAJ Thompson		1				1	1	1	1	1
FLTLT Ross		1					1	1	1	
Smith			1			1	1	1	1	1
Newcombe		1					1	1	1	1
FSGT Small		1							1	
Count	1	14	1	0	0	7	9	11	14	11
Percent	6.25	87.5	6.25	0	0	44	56	69	88	69

Airlift Planning Measure Response Summary

Measure **Flexibility**

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell		1					1	1		1
GPCAPT Harris	1					1	1	1	1	1
Miller		1						1		
WGCDR Peak	1								1	1
Thyer	1					1		1	1	1
Pryke		1				1	1	1	1	1
Frame		1				1	1	1	1	
SQNLDR Pottinger	1					1	1	1	1	1
Bradford	1						1			
Nattrass		1						1		
Green		1				1	1	1	1	1
MAJ Thompson	1					1	1	1		
FLTLT Ross		1				1	1	1	1	1
Smith		1				1	1	1	1	1
Newcombe		1				1	1	1	1	
FSGT Small	1						1			
Count	7	9	0	0	0	10	12	13	10	9
Percent	43.8	56.3	0	0	0	63	75	81	63	56

Airlift Planning Measure Response Summary

Measure — Certainty of Meeting Lift Requirements

Measure	Value of Measure: PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	Suitable Metric: 1	2	3	4	5
ACDRE Mitchell		1				1				1
GPCAPT Harris		1								
Miller		1				1				
WGCDR Peak					1	1				
Thyer	1					1	1			1
Pryke		1				1	1	1	1	1
Frame	1					1	1	1	1	
SQNLDR Pottinger		1				1	1	1	1	1
Bradford	1					1				
Nattrass		1				1				
Green		1				1	1	1	1	1
MAJ Thompson		1				1	1	1	1	1
FLTLT Ross		1				1	1	1	1	1
Smith					1					
Newcombe		1				1	1	1	1	1
FSGT Small	1					1				
Count	4	10	0	0	2	14	8	7	7	8
Percent	25	62.5	0	0	12.5	88	50	44	44	50

Airlift Planning Measure Response Summary

Measure	Accountability									
	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1					1
GPCAPT Harris					1					
Miller				1						1
WGCDR Peak		1								1
Thyer					1					
Pryke		1				1				
Frame		1								
SQNLDR Pottinger				1		1	1	1		1
Bradford		1				1				
Nattrass		1							1	
Green		1				1	1	1	1	1
MAJ Thompson	1					1	1	1		
FLTLT Ross		1				1	1	1	1	1
Smith					1					
Newcombe			1			1	1		1	
FSGT Small		1				1				
Count	1	8	1	2	4	8	5	4	4	6
Percent	6.25	50	6.25	12.5	25	50	31	25	25	38

Airlift Planning Measure Response Summary

Measure | Control

Measure	Value of Measure: PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	Suitable Metric: 1	2	3	4	5
ACDRE Mitchell			1				1	1	1	
GPCAPT Harris		1						1		
Miller				1					1	
WGCDR Peak					1				1	
Thyer	1									
Pryke		1				1	1	1		
Frame	1					1		1	1	
SQNLDR Pottinger	1					1	1	1	1	
Bradford		1						1		
Nattrass		1						1		
Green		1				1	1	1	1	
MAJ Thompson	1					1	1	1	1	
FLTLT Ross		1					1	1	1	
Smith			1			1	1	1	1	
Newcombe			1			1	1	1	1	
FSGT Small		1				1				
Count	4	7	3	1	1	8	8	12	10	0
Percent	25	43.8	18.8	6.25	6.25	50	50	75	63	0

Airlift Planning Measure Response Summary

Measure	Sensitivity									
	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell			1			1				1
GPCAPT Harris		1								
Miller					1	1				
WGCDR Peak					1			1		
Thyer		1				1		1	1	
Pryke		1				1	1	1	1	1
Frame					1					
SQNLDR Pottinger		1				1	1	1	1	1
Bradford		1				1				1
Nattrass		1							1	1
Green					1	1	1	1		
MAJ Thompson		1				1		1	1	1
FLTLT Ross			1					1	1	1
Smith		1			1	1		1		1
Newcombe			1			1	1	1		
FSGT Small										
Count	0	8	3	0	5	10	4	9	6	8
Percent	0	50	18.8	0	31.3	63	25	56	38	50

Airlift Planning Measure Response Summary

Measure	Format									
	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell			1						1	
GPCAPT Harris					1					
Miller			1				1			
WGCDR Peak					1		1			
Thyer		1				1	1	1	1	
Pryke		1								
Frame		1					1	1	1	1
SQNLDR Pottinger		1				1	1	1	1	1
Bradford	1					1	1	1	1	
Nattrass		1						1		
Green			1			1	1	1		
MAJ Thompson		1				1	1	1	1	1
FLTLT Ross		1				1	1	1	1	1
Smith		1				1	1	1	1	1
Newcombe		1				1	1	1	1	1
FSGT Small	1					1	1	1	1	
Count	2	9	3	0	2	9	12	11	10	6
Percent	12.5	56.3	18.8	0	12.5	56	75	69	63	38

Airlift Planning Measure Response Summary

Measure Speed

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell			1				1			
GPCAPT Harris					1					
Miller			1			1				
WGCDR Peak					1		1			
Thyer		1					1			
Pryke		1						1		
Frame		1					1			
SQNLDR Pottinger			1			1	1	1		
Bradford	1					1				
Nattrass					1	1				
Green		1				1	1	1		
MAJ Thompson		1				1	1	1		
FLTLT Ross		1				1	1	1		
Smith	1					1				
Newcombe		1				1	1	1		
FSGT Small	1					1				
Count	3	7	3	0	3	10	9	6	0	0
Percent	18.8	43.8	18.8	0	18.8	63	56	38	0	0

Airlift Planning Measure Response Summary

Measure — Security and Safety of Airlift Assets

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1					
GPCAPT Harris		1								
Miller					1					
WGCDR Peak					1	1				
Thyer	1					1				
Pryke	1					1	1	1	1	1
Frame		1				1	1	1	1	1
SQNLDR Pottinger		1				1	1	1	1	1
Bradford	1					1				
Nattrass		1								
Green			1			1	1		1	
MAJ Thompson	1					1	1	1	1	
FLTLT Ross	1					1	1	1	1	1
Smith				1		1	1	1	1	
Newcombe		1							1	1
FSGT Small	1					1				
Count	6	5	1	1	3	11	7	6	8	5
rcent	37.5	31.3	6.25	6.25	18.8	69	44	38	50	31

Airlift Planning Measure Response Summary

Measure | Security of Payload

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1					
GPCAPT Harris		1							1	
Miller					1					
WGCDR Peak					1					
Thyer	1									
Pryke	1					1	1	1	1	
Frame		1								
SQNLDR Pottinger		1								
Bradford			1				1			
Nattrass		1								
Green			1				1	1		1
MAJ Thompson		1					1		1	
FLTLT Ross	1					1	1	1	1	
Smith					1					
Newcombe			1			1	1	1	1	
FSGT Small				1						
Count	3	5	3	1	4	3	6	4	5	1
Percent	18.8	31.3	18.8	6.25	25	19	38	25	31	6.3

Airlift Planning Measure Response Summary

Measure | Concentration

	Value of Measure					Suitable Metric				
	PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED	1	2	3	4	5
ACDRE Mitchell					1		1			
GPCAPT Harris		1								
Miller					1					
WGCDR Peak					1			1		
Thyer			1				1			
Pryke		1				1	1	1		
Frame			1							
SQNLDR Pottinger		1				1	1	1	1	1
Bradford		1					1	1		
Nattrass		1					1			
Green			1				1	1	1	
MAJ Thompson	1					1		1	1	
FLTLT Ross		1							1	1
Smith			1			1	1	1	1	
Newcombe		1				1	1	1	1	1
FSGT Small		1					1	1		
Count	1	8	4	0	3	5	10	9	6	3
Percent	6.25	50	25	0	18.8	31	63	56	38	19

Airlift Planning Measure Response Summary

Measure: Summary of Factors

FACTORS	Value of Measure: PRINCIPAL	IMPORTANT	CONTRIBUTING	UNIMPORTANT	UNRELATED
Overall Effectiveness	81.3	13	0	0	6.3
Productivity	18.8	63	6.3	0	13
Economy	37.5	50	6.3	0	6.3
Efficiency	0	81	6.3	6.3	6.3
Simplicity of Plan	6.25	75	6.3	0	13
Training Value	0	31	50	0	19
Fluidity of Lift	6.25	81	6.3	0	6.3
Cohesion of Lift Entities	6.25	88	6.3	0	0
Flexibility	43.8	56	0	0	0
Certainty of Meeting Requirement	25	63	0	0	13
Accountability of Actions	6.25	50	6.3	13	25
Control	25	44	19	6.3	6.3
Sensitivity of Options	0	50	19	0	31
Format of Planning	12.5	56	19	0	13
Speed of Development	18.8	44	19	0	19
Security of Airlift Assets	37.5	31	6.3	6.3	19
Security of Payload	18.8	31	19	6.3	25
Concentration of Effort	6.25	50	25	0	19

Appendix D: Frequency and Size of ADF Airlift Operations

This appendix shows estimates of the size and frequency of ADF airlift operations. Data was first gathered from available previous ADF exercises. Estimates of size and frequency of three broad classes of operations were made by extrapolation from the data. These estimates were then reviewed by ADF personnel.

RAAF AIRLIFT PLANNING SYSTEM
OPERATION FREQUENCY STATISTICS

	Max	Min	Av	Confidence
Number of Operations requiring on-line access:				
-Fully developed state	8	2	3	.8
-Partially developed	20	5	10	.4
Number of Operations not on-line:				
-Fully developed state	15	0	0	.8
-Partially developed state	40	10	30	.6
-Archived from actual airlift per year	50	10	30	.7
Fully Developed Operation break-down:				
-Major, joint service (eg K89)				
-on-line	2	0	1	.9
-archived per year	2	0	1	.9
-Large, joint service (eg K92)				
-on-line	3	0	1	.8
-archived per year	4	2	2	.7
-Large, single service (eg Pitch Black)				
-on-line	3	0	1	.8
-archived per year	8	3	4	.7
-Medium, single/joint (eg Swift Eagle)				
-on-line	3	0	2	.8
-archived per year	15	4	5	.6
-Small, single service (eg Long Guns)				
-on-line	6	1	2	.7
-archived per year	30	20	25	.7
-Contingeny/Aid to the Community (Equals medium size exercise)				
-on-line	3	0	0	.8
-archived per year	4	1	1	.6
-Contingeny/Aid to the Community (Equals small size exercise)				
-on-line	4	0	0	.8
-archived per year	10	1	3	.6

RAAF AIRLIFT PLANNING SYSTEM
AIRLIFT SIZING STATISTICS

	Max	Min	Av	Confidence
Large Operations				
Missions:				
Military Aircraft	300	150	250	.7
Civil Aircraft	150	40	60	.4
Airfields:				
POEs	15	2	7	.8
PODs	15	3	10	.8
Customers:				
Units/Groups	180	30	60	.8
Passengers (Numbers '000)	25	5	12	.8
Freight (Tons '00)	10	2	5	.8
Period:				
ALG Planning and Airlift (Months)	12	1	2.5	.8
Period of Airlift (Months)	3	.5	1	.8
Medium Operations				
Missions:				
Military Aircraft	100	50	60	.6
Civil Aircraft	10	0	0	.6
Airfields:				
POEs	5	1	2	.6
PODs	7	1	4	.6
Customers:				
Units/Groups	60	20	25	.6
Passengers (Numbers)	5	1	3	.6
Freight (Tons)	5	1	2	.6
Period:				
ALG Planning and Airlift	3	.5	2	.6
Period of Airlift	2	.5	1	.6
Small Operations				
Missions:				
Military Aircraft	30	5	15	.6
Civil Aircraft	10	0	0	.3
Airfields:				
POEs	3	1	2	.4
PODs	5	1	3	.4
Customers:				
Units/Groups	15	3	7	.3
Passengers (Numbers)	2	.3	.6	.3
Freight (Tons)	1	0	.5	.3
Period:				
ALG Planning and Airlift	2	.2	.5	.5
Period of Airlift	1	.2	.4	.5

Appendix E: RAAF Airlift Planning System Functional Specification

This appendix provides a discussion of the RAPS functional specification. A functional specification lists essential things that a system must do. It provides the multiple objectives which require attribute definition and quantification for each development increment.

Requirements were sourced from a survey of ADF airlift planning personnel. The derived functional specification was endorsed by the sponsor of this research, the Deputy Director of Movements and Transport - RAAF (Peak, 1991b:20 June).

System Requirements

Executive system requirements fall into four groups: usefulness, user satisfaction, cost and control.

Usefulness

Usefulness involves issues of work capacity, availability and potential. The system should support the operator in making both structured and unstructured decisions in the planning of airlift. Additionally, the system should cater for unexpected forms of data interrogation and reporting.

The system's capacity must allow for exercises up to the size of larger joint service exercises, such as the Kangaroo series. The system must be capable of supporting the operation characteristics listed at Appendix D. Additionally, the system must be capable of supporting many operations simultaneously, though only five need be supported "on-line" at a fully developed state ie fully detailed airlift planning.

The system must be designed to perform in times of war or emergency. Consequently, the system must meet ADF privacy and security requirements, though extended options should provide for speedier communications and access when operations allow reduced security.

Availability addresses issues of portability, operator availability and processing delay. Operator availability needs require that the system allow operator access to data at all times. Preferably, all activities, including administration, should not restrict operator access to data. If unavoidable, short term limitations may be enforced in interests of data integrity or security. Through networking and sharing of resources, the system should allow operator access to data while processing unstructured decisions or extended output demands.

The system must be portable. Preferably, the system should be capable of operating on any "IBM PC" based architecture with minimal tuning and preparation. A "lap-top" capability is desired. Portable and home base versions of the system should have the same "look and feel", though the portable system need not support extended system requirements, including archiving and the ability to support more than one fully developed operation simultaneously.

Maximum potential for low cost and simple expansion and enhancement is sought. Therefore, flexibility and compatibility are principal requirements of design. The system must operate on a wide variety of IBM PC based systems and peripherals, with little tuning or changes. Where required, tuning must be able to be performed by the operator, via high level formatting menus. Software portability of data, inputs and outputs to general management systems such as word-processors and spreadsheets is also required.

The system must allow expansion of the data types captured and maintained by the system. Data management systems must allow for the format and presentation of data to be modified. The system must allow the operator to define report contents and formats. Preferably, the operator should only have to perform definition of new reporting requirements once.

User Satisfaction

User satisfaction is divided into three sections: input and output, response and experience required. Input and output deals with maximising the usefulness and accuracy of data, while minimising operator time. The system must provide simple and speedy input of data, with minimum keystrokes. Data accuracy and integrity should be checked at input where possible. The ability to "batch import" data from other systems, electronically, must be provided.

Data should only be reported to the system once. Therefore, data captured for use with an operation should be retained by the system, if useful, for application to subsequent operations. Additionally, the system should possess the ability to glean information from decisions of the operator, for example, if the operator identifies an airfield or what constitutes a full load.

The operator must have interactive access to the system and response time must be acceptable. Response time may vary with the complexity and repetitiveness of the task. Simple amendments, frequently performed operations and reports should be quickly processed while more complex tasks may take longer. An upper bound of two hours is placed on all response times. All tasks where response time will be

more than ten minutes must advise the operator and receive confirmation to proceed.

While allowing a high degree of expertise in the routing and planning of airlift, the system can only rely upon minimum computer skills of operators. Limited availability of planners for training means that the system should require little formal training prior to use. The system should allow inexperienced users to quickly reach efficiency through user friendly programming and an "on-board" training package.

Cost

Cost involves resource control, including aspects of money and time. Financial costs include new equipment purchases and installation and recurring outlays. The system must be capable of running on a wide variety of personal computer level systems. No specialist hardware should be required and the system should cater for most printer, screen and storage configurations.

Manpower and calendar time is limited in all aspects of the development cycle, including design, coding, documentation, supervision and management, and maintenance. The system should use commercial systems where possible. Additionally, systems management and administration should be automated and require little computing expertise to perform. Complete documentation should be presented both in hard copy and electronic form to allow for simple amendment and reproduction. Preference would be given to a system that provided systems documentation in a "hypertext" form.

Control

Reliability, maintainability and interface comprise the components of control. Data maintained by the system must be of sufficient accuracy and completeness to support system operations and operator requirements. The system must offer an audit function that, at minimum, provides an executive and detailed summary of decisions taken and data changed during the course of an operation.

Software maintainability must be supported through detailed documentation of procedures, code and data structure. Suitable tools of design should be used to ensure accurate and ready presentation of data flow, decision paths and relations between data and system components. Design tools and languages should have good recognition and use across the general computing industry, and preferably the ADF.

The requirement for all hardware to be standard meets requirements for hardware maintainability. Standardisation refers to both internal and external industry norms.

The system requires interface with manual and automated systems. Some of these systems form part of the airlift system, while others are external. All systems should have access to electronic forms of data and output, with a minimum being the common industry formats, an example of which is ASCII files on 5.25 inch flexible floppy disks. Some internal airlift agency systems, such as air terminal operators and flying squadrons, will require direct electronic link to the system.

Summary

A summary list of functional criteria follows.

AIRLIFT PLANNING SYSTEM CRITERIA

User Satisfaction	-- Input/Output	-- Speed Ease of modification Validation of Input Ease of use
	-- Response	-- Response time Simple decision support Complex decision support
	-- Experience needed	-- Airlift knowledge Computing knowledge
Usefulness	-- Work capacity	-- Allowed volume Capacity of system
	-- Availability	-- Portability Processing delay Accessibility
	-- Potential	-- Flexibility Compatibility
Control	-- Reliability	-- Data integrity Data completeness Accountability Audit
	-- Maintainability	-- Hardware independence Simplicity Standardisation
	-- Interface	-- External Internal primary Internal secondary
Cost	-- Money	-- New Equipment Installation Communications Recurring maintenance Recurring consumables
	-- Time	-- Design Programming Testing and documentation Maintenance Hardware conversion Management and supervision

Appendix F: User Evaluation of System Needs

This appendix provides results of a survey question where ADF airlift planners were asked to rank functions being considered for an airlift planning MIS. Raw and summarised results are presented.

In the last question of the "Management Information System Goals" section of the survey, planners were asked to rank functions in order of desirability. Scores from "one" upwards were used to show desirability, with a "one" meaning most desirable.

Narrow descriptions of options were provided to ensure recognition of functions. However, wider functions are used for the review. For each planner, similar functions are grouped and a "one" to "five" ranking for the wider functions derived.

Three types of summary results are calculated. The first is an overall assessment. For this, the "one" to "five" scores derived for each respondent are tallied by function. A lower total means greater perceived importance across planners. To reflect this in the overall percentage ratings for each function, totals are first subtracted from the largest possible score ("five" from each respondent).

The second summary result is a count of the number of "one" scores, meaning most important, each function received. Percentages are derived by dividing this count by the number of respondents, in a similar fashion to rank sum statistics.

The last summary statistic is a count of the number of "one" or "two" scores each function received. Combining "one" and "two" scores gave better indication of importance of factors across planners. Percentages are also derived using twice the number of respondents.

RAAF Airlift Planning System
Function Rating

Respondent	TRANSACTION & DATABASE	ROUTING & SCHEDULING	INTERFACE	EXECUTIVE CONTROL	AUDIT & REVIEW
ACDRE Mitchell	3	1	5	4	2
GPCAPT Miller	1	5	2	4	3
WGCDR Peak	2	1	4	5	3
Thyer	2	5	1	3	4
Frame	2	3	1	5	4
SQNLDR Pottinger	2	1	4.5	4.5	3
Bradford	1	5	2	3	4
Nattrass	3	1	2	4.5	4.5
Green	5	1	4	2	3
MAJ Thompson	1	3	4	2	5
FLTLT Ross	2	1	5	3	4
Smith	1	2	5	3	4
Newcombe	1	2	5	3	4
FSGT Small	5	3	1	4	2
Count	31	34	45.5	50	49.5
Overall % Rating	56	51	35	29	29
Most Important	5	6	3	0	0
Percentage	36	43	21	0	0
Top Two Importance	10	8	6	2	2
Percentage	71	57	43	14	14

Appendix G: RAAF Airlift Planning System Increment One Prototype Design

This appendix contains an overview of the prototype RAPS system. The prototype provides database and load estimation functions specified in development increments one and two. Prototype discussion addresses transaction and database design.

The prototype has the following basic development and operating environment:

1. a micro-computer based system under DOS 3.0 or higher operating system control,
2. 80286/80386 architecture hardware,
3. large capacity hard disk storage availability, which is managed by the operating system BIOS, and
4. application of a RDBMS, a hypertext system and other third party software.

Transaction Design

User access to actions is based on a tiered menus. Users pass through levels of menus until the desired activity is reached. On-line help is provided at each menu and users can navigate their way to transactions without need of look-up lists of transaction names.

Transactions are grouped by activity and global or operation level of impact. Security of data is provided by access screening at various levels of the menu tree. The RAPS prototype menu tree follows.

RAAF Airlift Planning System (RAPS)
Application Menu Tree

```
Main - *
      - System -
               - Global -
                        - Airlift -
                                   - Aircraft -
                                              - New [ Data Entry ]
                                              - Existing -
                                                         - Edit [ CoEdit ]
                                                         - Notes [ CoEdit ]
                                                           Help [ HyperText Access ]
                                              - Print [ Report ]
                                              - Help [ Hypertext Access ]
                                   - Locations -
                                               - Location -
                                                          - New [ DataEntry ]
                                                          - Existing -
                                                                     - Edit [ CoEdit ]
                                                                     - Notes [ CoEdit ]
                                                                     - Help [ HyperText Access ]
                                                          - Help [ Hypertext Access ]
                                                 DaylightSavings -
                                                                 - New [ DataEntry ]
                                                                 - Existing [ CoEdit ]
                                                                 - Help [ Hypertext Access ]
                                                 Timings
                                                         - New [ DataEntry ]
                                                         - Existing [ CoEdit ]
                                                           Help [ Hypertext Access ]
                                               - Reports -
                                                           Identifier [ Report ]
                                                           Name [ Report ]
                                                         - Zones [ Report ]
                                                         - Times [ Report ]
                                                           Help [ Hypertext Access ]
                                               - Help [ Hypertext Access ]
                                   - Help [ Hypertext Access ]
                        - Units -
                                - New [ DataEntry ]
                                - Existing -
                                           - Edit [ CoEdit ]
                                           - Notes [ CoEdit ]
                                           - Help [ HyperText Access ]
                                - Print [ Report ]
                                - Help [ Hypertext Access ]
                        - Loadplanning -
                                       - Passenger [ CoEdit ]
                                       - General [ CoEdit ]
                                       - Hazardous [ CoEdit ]
                                       - Wheeled [ CoEdit ]
                                       - Reports [ Report ]
                                       - Help [ Hypertext Access ]
```

```
        - Reports [ Report ]
#       - Help [ Hypertext Access ]
- Operations -
            Initial
                    - DecideLoads -
                                  - Allocate  [ DataEntry ]
                                  - Review [ CoEdit ]
                                  - Kill [ Table Delete ]
                                  - Print [ Report ]
                                    Help [ Hypertext Access ]
                    - Route&Schedule -
                                     - HardResourceLimits -
                                                            Start [ DataEntry ]
                                                          - Continue [ CoEdit ]
                                                          - End [ Exit ]
                                                          - Kill [ Table Delete ]
                                                          - Print [ Report ]
                                                          - Help [ Hypertext Ac ]
                                       SoftResourceLimits
                                                          - Start [ DataEntry ]
                                                          - Continue [ CoEdit ]
                                                          - End [ Exit ]
                                                          - Kill [ Table Delete ]
                                                          - Print [ Report ]
                                                          - Help [ Hypertext Ac ]
                                     - Help [ Hypertext Access ]
                    - FormPlan -
                               - Hard [ Procedure Initiation ]
                               - Soft [ Procedure Initiation ]
                                 Continue [ Processing ]
                                 Quit [ Exit ]
                               - Help [ Hypertext Access ]
                    - Help [ Hypertext Access ]
            OrderofMarch
                         - New [ DataEntry ]
                         - Existing [ CoEdit ]
                         - Help [ HyperText Access ]
          - Hours/Frames -
                         - Hours [ CoEdit ]
                         - GeneralFrames [ CoEdit ]
                         - SpecificFrames [ CoEdit ]
                         - Help [ Hypertext Access ]
          - Plan
                - New [ DataEntry ]
                  ?
                  Existing
                           - Loads -
                                   - New [ DataEntry ]
                                   - Existing [ CoEdit ]
                                   - Move [ CoEdit ]
                                   - Help [ HyperText Access ]
                           - Modify [ CoEdit]
                           - Replicate -
                                       - SameDay [ CoEdit ]
```

```
                                                  - Dayly [ CoEdit ]
                                                    Weekly [ CoEdit ]
                                                  - Fortnightly [ CoEdit ]
                                                  - Monthly -
                                                            - DOWSame[ CoEdit ]
                                                            - SameDateInMonth[ CoEdit ]
                                                            - Help [ HyperText Access ]
                                                  - Help [ HyperText Access ]
                                      - Split [ CoEdit]
                                      - Join [ CoEdit]
                                      - Print -
                                              - Green [ Report ]
                                              - ModalInst [ Report ]
                                                Help [ HyperText Access ]
                                      - Help [HyperText Access ]
                          - Help [ Hypertext Access ]
                      Actual
                                Payload [ DataEntry ]
                                Flights [ DataEntry ]
                                Help [ Hypertext Access ]
                    - Check -
                            - Parking [ Process ]
                              Airframes [ Process ]
                            - FlyingTime [ Process ]
                            - Help [ Hypertext Access ]
                      Reports
                                Resource -
                                          - Airframe [ Report ]
                                            FlyingHours [ Report ]
                                          - Tasks [ Report ]
                                          - Payload [ Report ]
                                            Help [ Hypertext Access ]
                              - OrderofMarch -
                                              - OrderofMarch [ Report ]
                                              - ActualvsDefined [ Report ]
                                              - Help [ Hypertext Access ]
                              - AirliftPlan [ Report ]
                              - Greens -
                                        - New [ Report ]
                                        - Changes [ Report ]
                                        - Help [ HyperText Access ]
                              - Help [ Hypertext Access ]
         @          - Help [ Hypertext Access ]
         - SystemManagement [ NotDefined ]
         - Help [ Hypertext Access ]
  - Help [ Hypertext Access ]
  - Play [ DOS Call ]
  - Leave [ Leave ]
```

Notes:

* * - User inputs identification and password
* \# - User selects desired operation from those available to the user
* @ - A check is performed to ensure user has system manager status
* ? - A restricted search of operation's tasks based on user definition is offered

Global transactions address activities that affect all operations on the system. Global data is consistent across operations and is centrally managed and stored in one location. Global data includes information concerning aircraft, airfields, time differences, ADF units and set-ups for the RAPS loadplanning model.

Users with access to the system can affect global data, though transactions available to classes of users can be limited by the system manager. Because global data can be used by more than one operation, users cannot delete record entries. And any changes to records are cascaded to relevant operations' data.

Users also can add notes against aircraft, airfields and units. These notes, which have defined currency period, are displayed to other users when they select the global element while planning. This allows changes in availability or location to be quickly advised to all users.

Load planning set-up allows users to specify characteristics of classes of passengers and freight.

Users can only access operations where they have sufficient RAPS security clearance or hold specific authority to access an operation. Within an operation, users can define and amend the order of march and resource limits, perform load estimation and airlift scheduling and generate an air mode plan, amend flow or payload detail and call various reports. The routing and scheduling component is unavailable in the prototype.

Database Structure

RAPS files include system, help information, airlift data and report output files. System files refer to programs and libraries

required to run the system. They may include Paradox[R] RDBMS suites, RAPS specific routines and other third party supplied suites, such as spreadsheet systems.

Help files include hypertext routines and screen display text and graphics data used for interactive training and novice message displays. Hypertext routines include run-time versions of HyperReader[R].

Data includes all files established and maintained by RAPS. Output files include any output that users request not be sent to a printer but to a file.

Data files are maintained by the Paradox RDBMS[R]. Data is either global to all operations or specific to each operation. To meet this requirement, the following file structure is used:

```
Root
  - RAPS  -contains system files and no data.
      - INFO - contains help and novice hypertext files.
        GLOBAL - contains data not unique to operations.
      - DATA - contains report output files.  These files
                  occur where a user has elected to send
                  output to a file.
        OPS - contains no files.
          - R_xxxxxx - contains data for operation xxxxxx
            :
          - R_xxxxxx - contains data for another
                          operation.
```

Database Entities

Entities normally refer to relations or tables that maintain data for a relational database. A naming convention is applied the RAPS entities.

RGLocati

Entity contents. An abbreviation, up to 6 characters long, that describes the file contents.

Entity family. The group of files that the entity belongs to. The family indicates the file's directory location and impact of data.

Always 'R' to denote a RAPS file.

Entity Family

Entity family gives indication of file types, information content and the directory location of stored files. Allowable family entity values are:

1. G, global data which relates to all operations or to system settings,

2. O, data specific to an operation,

3. M, operations specific data related to miliary uplift,

4. C, operations specific data related to civil charter uplift,

5. R, operations specific data related to civil regular public transport (RPT) uplift.

Attribute Naming

Attributes normally refer to columns in a relation. Each occurrence of a record has a unique combination of attribute occurrences. These attributes combine to give the structure of a database relation. Designers use the attribute name to refer to scalar values of a tuple.

GL_Month

Attribute identifier. An alphanumeric combination, to a maximum of 25 characters, that describes the attribute's contents. Spaces are not allowed.

Always a '_', to improve readability.

Entity identifier. A letter that uniquely describes each relation. It is the first letter of the entity contents .

The entity family.

Relation Entity Data Dictionary Conventions

Each entity relation data dictionary entry will comprise the following elements:

1. Entity Name: A unique title of the relation. Uniqueness must only be maintained within a directory for operation specific data ie relations with the same name, but different data, may exist across operations.

2. Long Name: Full title of the entity, to a maximum of 30 alphanumeric characters. Spaces are allowed.

3. Purpose: A short statement of the role and application of the entity in the system. A maximum of 150 alphanumeric characters are allowed, including spaces.

4. Directory Location: A one letter code giving the general location of the file representing the relation in secondary storage. Options are:

(i) Global (G), and

(ii) Operation (O) - meaning within each operation's directory.

Other data is held for each entity, including: number of global and operation instantiations (number of records in each entity),

references or reasons that support instantiation estimates and the date of the last change to the relation entity entry.

Relation Attribute Data Dictionary Conventions

Within each relation, its attributes are defined by:

1. Attribute Name: The attribute title in accordance with the relation attribute naming convention. This title must uniquely identify the attribute within the relation or entity.

2. Format: The form represented by the attribute. Format applies syntax to define storage and presentation requirements. Values are derived from multiples of:

(i) numbers only - 9,

(ii) decimal values - V (only with numerics),

(iii) sign - S (only with numerics where negatives may exist)'

(iv) alphanumeric - X,

(v) alphabetic - A,

(vi) date, in the form ddmmmyy - D, and

(vii) a pointer to a file record - P.

Example: 9(3)V99 -> means a decimal with range 0 through 999, including two decimal places.

3. Full Title: A proper description of the attribute.

4. Purpose: A short statement of the role and application of the attribute in the system.

5. Attribute Dependency: Attribute dependency indicates the relation between the attribute and other attributes in its relation and other relations. Options are:

(i) Primary - the attribute is, or forms part, of the primary key for the relation. A primary key can uniquely identify all occurrences of tuples/records in the attribute's relation.

(ii) Dependent - the attribute is functionally dependent on other attributes in the relation. Being functional dependent means that the attribute occurrence can be determined by other attribute(s) in the relation. These other attributes usually form the primary key.

(iii) Foreign - a dependent that is a key to another attribute. A foreign key is determined by the primary key, yet provides part or all of the primary key to another relations. Foreign keys are used in relational databases to link relations. Where a foreign key is also a primary key, its attribute dependency is defined as primary.

Other definitions of attributes are used in the complete description, including the domain which provides those values that the attribute can take, the date of the last change to the relation attribute entry and a description of the latest changes to the relation attribute entry.

The RAPS prototype has 35 relations containing 266 attributes.

Summary of RAPS Entities

Entity Title	Long Name	Purpose
Relation Level: Global, Non-Operation Specific		
RGAcft	Global Military Aircraft Data	Provides military aircraft operating squadron and descriptive data
RGCargo	Global Cargo Definition	Defines regularly moved cargo inc wt, dim and haz class
RGFretWt	Global Freight Classes	Defines conversion factor from wt to linear feet for classes of freight
RGIntTm	Global Interairfield times	Provides times between two airfields - these times override the times computation
RGLocat	Global Airfield Data	Data on airfields - location, time zone and full name
RGMSer	Global Military Green Sequence	Maintains sequence of aircraft tasking numbers (splits into monthly groups)
RGNotes	Global Notes on Elements	Maintains recent notes to planners on aircraft, airfields and units
RGPLoads	Global Planned Loads	Aircraft loads for automated planning of airlift
RGRUsers	RAPS Users	Maintains authorised users and access level
RGSettin	Global Operations Current	Lists operations current and access requirements
RGUnits	Global Unit Data	Provides unit names, command and message addresses for units in system
RGVehLen	Global Average Vehicle Lengths	Provides a conversion between vehicle type and average length of C130 cargo space required
RGWeight	Global passenger weights	Provides standard weights for passenger classes
RGZoneDS	Daylight Savings data	Maintains day light savings settings for each state/country
Relation Level: Operation Specific		
RMALimit	Hours and Airframe Limits	Stores hours and airframe limits by phase and military aircraft type
RMChange	Task Changes by Type and Phase	Keeps counts of task changes by aircraft type and phase
RMDLimit	Specific Day Airframe Limits	Stores limits imposed on an airframe type on specific days ie servicings
RMGreens	Military tasks	Maintains headers for all military airlift for all phases
RMHou[illegible]	Actual Military Hours Flown	Maintains monthly statistics of actual hours flown
RMNarrat	Green Narrative for Mil Tasks	Records narrative comments for greens for military lift
RMTasks	Military Task Flight Legs	Maintains task leg and green data for military tasks
ROHardA	Hard initial C130 plot	Records date of lift and combinations of entities on C130 lift, using the hard resource algorithm
ROISoft	Soft initial C130 plot	Records date of lift and combinations of entities on C130 lift, using the soft resource constraint algorithm
ROLoads	Payloads for Flights	Maintains planned and actual payload for military and civil flights
ROMarOrd	Order of March	Ties units to serials and stores original lift requirement
ROOUsers	Operation Users Statistics	Records actions of system users for each operation
ROPCDate	Payload Changes by Time	Keeps counts of payload changes tracked against time till lift occurs
ROR&Sch	Initial Routing Loads	Assigns the order of march to loads and aircraft type
ROSettin	Operations Settings/Config	Contains settings and configuration for an operation
ROTkLock	Operations Level Task Locking	Maintains locked tasks within each operation
ROUnits	Operation unit data override	Maintains temporary unit detail. Data in this relation overrides entries in the global relation RGUnits.
RPGreens	RPT Tasks	Maintains headers for regular public transport airlift for all phases
RPTasks	RPT Flight Legs	Maintain task leg and green data for regular public transport flights
RQGreens	Civil Charter Tasks	Maintains headers for civil charter airlift for all phases
RQTasks	Civil Charter Flight Legs	Maintains task leg and green data for civil charter flights

35 Relations

Relation Attribute List

Entity Title: RGAcft Entity Location: (Global or Operation Specific): G
Entity Description: Global Military Aircraft Data
Entity Purpose: Provides military aircraft operating squadron and descriptive data

Attribute Name	Dep/Format	Full Title	Purpose
GA_Acft	P X(6)	Military aircraft designator	Allows tasks to be grouped by a recognised aircraft type. Supports edits of user input of military aircraft type. Only used with military a/c
GA_Home	F X(5)	Home base	Used to generate tasking and route and schedule
GA_Sqn	F X(15)	Squadron operating aircraft	Links the aircraft type to msg and command detail for the unit operating the aircraft
GA-Cost	D 9(4)	Flying hour cost	Used in reports that summarise and cost airlift effort
GA_Burn	D 9(5)	Burn rate per hour	Used in estimating refuel requirements
GA_Callsign	D X(10)	Squadron identifier	Allows callsign to be output on the aircraft tasking green as required
GA_Crew_Day	D 9(2)V9	Planning Crew day	Used to check task capability
GA_Crew_Rest	D 9(2)V9	Planning crew rest	Used to check task capability
GA_CTG_Designator	D X(10)	Squadron CTG/CTS	Presence of a CTG/CTS starting with 646 identifies that a green can be generated against the aircraft type ie C130E would have a CTG but C130 wouldn't
GA_Desc	D X(30)	Aircraft description	Describes the aircraft type and differentiates different rigs
GA_Max_Fuel	D 9(6)	Maximum fuel load	Used to check leg capability
GA_Max_Pax	D 9(3)	Maximum pax	Planned lift is checked against this value by the proofer. Planned pax no. can exceed this, though proofer will give a warning
GA_Max_Payload	D 9(6)	Maximum planning payload	Used to check leg capability
GA_Speed	D 9(3)	Aircraft planning speed	Used to calculate flight time between two lat/longs
GA_Turnaround	D 9(2)V9	Aircraft turnaround time	Used in calculating task timings
GA_Type	D X(6)	Base aircraft type	Used in green generation to denote aircraft type

Entity Title: RGFretWt Entity Location: (Global or Operation Specific): G
Entity Description: Global Freight Classes
Entity Purpose: Defines conversion factor from wt to linear feet for classes of freight

Attribute Name	Dep/Format	Full Title	Purpose
GF_Class	P X(1)	Class of cargo	Allows a freight group to have different classes of characteristics
GF_Description	D X(40)	Description of freight class	Assists user decide on an accurate freight class
GF_LF_LB_Conversion	D 9(4)	Pounds to linear foot conversion	Required to estimate loads for initial routing and scheduling. Calculated by user averaging mix of classes and storing av LF/LB factor in ROMarOrd
GF_With_Pax_On_Side	D X(1)	Passengers possible beside freight	Used to determine loads for router and schedular

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RGIntTm	Entity Location: (Global or Operation Specific): G	
Entity Description:	Global Interairfield times		
Entity Purpose:	Provides times between two airfields - these times override the times computation		
GI_Field_1	P X(5)	Airfield 1	Denotes one airfield key
GI_Field_2	P X(5)	Airfield 2	Denotes second airfield key
GI_Time_1_2	D 9(2)V9(2)	C130 flight time from 1 to 2	Used to manually override the distance based flying time between airfields calculation
GI_Time_2_1	D 9(2)V9(2)	C130 flight time from 2 to 1	Used to manually override the distance based flying time between airfields calculation

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RGMSer	Entity Location: (Global or Operation Specific): G	
Entity Description:	Global Military Green Sequence		
Entity Purpose:	Maintains sequence of aircraft tasking numbers (splits into monthly groups)		
GM_Month	P X(3)	Series month	Allows greens to be maintained by month series or as planned (planned is a revolving series 1000-2999 in AAA month)
GM_Current	D 9(4)	Last green used in the month	Allows unique application of task registrations per month or as planned

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RGNotes	Entity Location: (Global or Operation Specific): G	
Entity Description:	Global Notes on Elements		
Entity Purpose:	Maintains recent notes to planners on aircraft, airfields and units		
GN_Key	P X(15)	Element title	Allows notes to be tied to a record in RGAcft, RGLocat or RGUnits
GN_Sequence	P X(1)	Note number for element	Listing key for note, allows access to specific notes
GN_Type	P X(1)	Element type	Avoids problem if a unit had same name as an aircraft type or location etc
GN_Author	D X(7)	Author of note	Authors name gives authority and reference to the note
GN_Kill date	D D	Date note to be deleted	Allows old notes to be dropped from the system
GN_Note	D X(150)	Note concerning element	Maintains short term information, concerning a aircraft type, location or unit, for operators
GN_Start_date	D D	Date note entered	Shows newness of note

Entity Title: RGLocat Entity Location: (Global or Operation Specific): G
Entity Description: Global Airfield Data
Entity Purpose: Data on airfields - location, time zone and full name

Attribute Name	Dep/Format	Full Title	Purpose
GL_Location	P X(5)	Location identifier	Ties flights and lift to proper airfield abbreviations
GL_Time_DL_State	F X(5)	State/country standard for daylight savings change	Acts a foreign key for GZ_State to find daylight savings changes for the airfield
GL_Unit_Operating	F X(15)	Airfield load coordination agency	Allows greens to be addressed to air movement agencies and specifies which airfields require load reports etc
GL_Additional_MSg_1	D X(20)	Additional message address	Allows Base Ops and HQ to be included on tasks to airfields
GL_Additional_MSg_1_For	D X(30)	Distribution of additional message	Allows distribution field on aircraft taskings
GL_Additional_MSg_1_Prec	D X(1)	Message precedence	Used to decide precedence of addressees on tasking messages
GL_Additional_MSg_2	D X(20)	Additional message address - 2	Allows additional message addresses to be identified for a location
GL_Additional_MSg_2_For	D X(30)	Distribution of second additional message	Allows distribution field on aircraft taskings
GL_Additional_MSg_2_Prec	D X(1)	Message precedence - 2	Used to decide precedence of addressees on tasking messages
GL_Airfield_Title	D X(25)	Airfield title	Allows user to identify airfield bearing unusual identifier
GL_Alternate_Code	D X(5)	Alternate airfield abbreviation	Allows users to nominate a location based on a de-facto airfield abbreviation eg TVL for ABTL
GL_Lat_Deg	D 9(3)	Latitude degrees of airfield	Combines with minute and second values to give lat of airfield. Used in distance and flying time calculations
GL_Lat_Min	D 9(2)V9(2)	Latitude minutes and seconds	Combines with degree value to give lat of airfield.
GL_Long_Deg	D 9(3)	Longitude degrees of an airfield	Combines with minute and second values to give long of airfield. Used in distance and time calculations
GL_Long_Min	D 9(2)V9(2)	Longitude minutes and seconds	Combines with degree value to give long of airfield
GL_Max_Parking	D 9(2)	Maximum aircraft allowed on ground	A test value for proofing of a plan. The plan can exceed this no. but the proofer gives a warning
GL_Time_Close	D 9(4)	Closing time, local time based	A test value for proofing of a plan. Movement can occur after this time, though the proofer will provide a warning
GL_Time_Open	D 9(4)	Opening time, local time based	A test value for proofing of a plan. Movement can occur prior to this time, though the proofer will provide a warning
GL_Time_Zone	D S9(2)V(9)	UTC Standard time correction	Allows reports to nominate local times. Times specify standard times. GL_State keys to daylight savings provisions

Entity Title: RGRUsers Entity Location: (Global or Operation Specific): G
Entity Description: RAPS Users
Entity Purpose: Maintains authorised users and access level

Attribute Name	Dep/Format	Full Title	Purpose
GR_User	P 9(2)	User code	User's code cannot be changed by users and is the key to other files accessing user data
GR_Access_Level	D 9(1)	User access level	Access levels to RAPS operations range from 0, no restriction, through 9, highest restriction
GR_Access_Special	D X(1)	User special access	Used where a user is a guest to the system and requires access to only one family of operations and not all operations at the normal access level
GR_Output_Report_No	D 9(3)	User report tally	Keeps a running series of reports sent to disk for each user to allow file names to be different for each report sent by a user
GR_Password	D X(15)	User password	Secret password to RAPS operations data
GR_Password_Date	D D	User password date	Supports users being forced to change password regularly
GR_User_Class	D X(4)	User classification	The level of users in the organisation allows restrictions on transactions to be applied according to responsibility and authority
GR_User_Name	D X(7)	User name	User's log-in is the name users input when first entering RAPS. Allows access to other user data

Entity Title: RGSettin Entity Location: (Global or Operation Specific): G
Entity Description: Global Operations Current
Entity Purpose: Lists operations current and access requirements

Attribute Name	Dep/Format	Full Title	Purpose
GS_Acronym	P X(7)	Recognised acronym for operation	Allows users to enter the desired operation based on a meaningful key
GS_Access_Level	D 9(1)	Required access level	The higher the number, the less users will have access to the operation. Allows operations to be downgraded/restricted from all users. Refer GR_Access
GS_Controller	D X(7)	Designated operation controller	Allows the system manager to identifier the controlling authority for an operation
GS_Description	D X(60)	Brief description of the operation	Provides users with assistance in choosing desired operation
GS_Dir	D X(8)	Directory containing operation data	Directs paradox to the operation's data directory
GS_End Date	D D	Operation end date	Defines a time bound for the operation. Improves editing of dates by system
GS_Special_Access	D X(1)	Special access code	Allows a guest to have access to specific operations only
GS_Start Date	D D	Operation commence date	Defines a time bound for the operation. Improves editing of dates by system
GS_Wind_From_West	D S9(2)	Planning wind speed from the west	Defined at set-up of operation to allow crude recognition of consistent wind from the west. A negative value would mean an Easterly

Relation Attribute List

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RGUnits	Entity Location: (Global or Operation Specific): G	
Entity Description:	Global Unit Data		
Entity Purpose:	Provides unit names, command and message addresses for units in system		
GU_Unit	P X(15)	Recognised unit abbreviation	Used to tie payload to a unit's detail and edit user input of unit
GU_Command	F X(15)	Units command	This field points to the RGUnits entry for the unit's command
GU_MSg_Address	D X(20)	Recognised message address for unit	Used to address messages for squadrons, ams/mcos and customers
GU_MSg_For	D X(30)	Distribution for message at destination	Allows distribution field data on aircraft taskings
GU_Title	D X(35)	Proper unit title	Used to address and head reports

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RGVehLen	Entity Location: (Global or Operation Specific): G	
Entity Description:	Global Average Vehicle Lengths		
Entity Purpose:	Provides a conversion between vehicle type and average length of C130 cargo space required		
GV_Class	P X(1)	Class of wheeled cargo within type	Key to average length of wheeled cargo
GV_Type	P X(3)	Type of wheeled cargo	Key to average length of wheeled cargo
GV_Av_Length_Of_C130	D 9(3)	Average length of type and class	Average length of wheeled cargo used in estimating aircraft loads required. Figure is average length of C130 floor required to lift av. cargo of the

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RGWeight	Entity Location: (Global or Operation Specific): G	
Entity Description:	Global passenger weights		
Entity Purpose:	Provides standard weights for passenger classes		
GW_Pax_Type	P X(1)	Code referencing categories of passengers	Used to key from payload file in standard passenger weight
GW_Pax_Desc	D X(20)	Description of passenger in class	Describes the components carried on the person by somebody in the class
GW_Pax_Weight	D 9(3)	Weight of passenger class	Used to calculate payload figure involving passengers (different classes of passengers carry different baggage weights)

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RGZoneDS	Entity Location: (Global or Operation Specific): G	
Entity Description:	Daylight Savings data		
Entity Purpose:	Maintains day light savings settings for each state/country		
GZ_State	P X(5)	State/country code for airfield	Used to key into required daylight savings adjustment
GZ_Change	D S9V9	Effect of daylight savings change	Daylight savings value applied
GZ_Date_Finish	D D	Finishing date for daylight savings	Used to calculate if daylight savings adjustment is required
GZ_Date_Start	D D	Starting date for daylight savings	Used to calculate if daylight savings adjustment is required
GZ_UTC_Conv	D S9(2)V9	UTC conversion for region	Used as an indicative local time conversion value in location airfield changes

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RMALimit	Entity Location: (Global or Operation Specific): O	
Entity Description:	Hours and Airframe Limits		
Entity Purpose:	Stores hours and airframe limits by phase and military aircraft type		
MA_Acft	P X(6)	Military basic airframe designator	Allows hours to be recorded by generic and recognisable aircraft type
MA_Frames_Per_Day	D 9(2)	Maximum airframes allocated per day	Used to provide airframe per day statistics
MA_Hrs_Deploy	D 9(4)	Hours earmarked to deployment phase	Used to provide performance statistics for each phase of an operation
MA_Hrs_Maint	D 9(4)	Hours earmarked to maintenance phase	Used to provide performance statistics for maintenance phase
MA_Hrs_Redeploy	D 9(4)	Hours earmarked to redeployment phase	Used to provide performance statistics for redeploy phase
MA_Overall_Hours	D 9(4)	Hours allocated for airframe type	Maintains limits imposed on airframe hours

Attribute Name	Dep/Format	Full Title	Purpose

Entity Title: RMChange Entity Location: (Global or Operation Specific): O
Entity Description: Task Changes by Type and Phase
Entity Purpose: Keeps counts of task changes by aircraft type and phase

MC_Acft	P X(5)	Military basic airframe designator	Allows changes to tasks to be recorded by aircraft type
MC_Phase	P X(1)	Phase of operation	Allows changes to tasks to be recorded by operation phase
MC_Adds	D 9(4)	Number of task additions	Allows change statistics to be maintained on military airlift planning for an operation
MC_ALG	D 9(4)	Number of task changes caused by mode operator	Allows change statistics to be maintained on military airlift planning for an operation
MC_Changes	D 9(4)	Number of task modifications	Allows change statistics to be maintained on military airlift planning for an operation
MC_Cust	D 9(4)	Number of task changes caused by customer	Allows change statistics to be maintained on military airlift planning for an operation
MC_Drops	D 9(4)	Number of task deletions	Allows change statistics to be maintained on military airlift planning for an operation
MC_MC	D 9(4)	Number of task changes caused by movement control	Allows change statistics to be maintained on military airlift planning for an operation
MC_Other	D 9(4)	Number of task changes caused by other players	Allows change statistics to be maintained on military airlift planning for an operation

Attribute Name	Dep/Format	Full Title	Purpose

Entity Title: RMDLimit Entity Location: (Global or Operation Specific): O
Entity Description: Specific Day Airframe Limits
Entity Purpose: Stores limits imposed on an airframe type on specific days ie servicings

MD_Acft	P X(6)	Military basic airframe designator	Allows limits to be recorded against a generic and recognisable airframe type
MD_Day	P D	Date in form dd/mm/yy	Allows airframe limits to be defined for a specific day
MD_Limit	D 9(2)	Airframe limit	Allows airframe limits to be defined for a specific day

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RMGreens	Entity Location: (Global or Operation Specific): 0	
Entity Description:	Military tasks		
Entity Purpose:	Maintains headers for all military airlift for all phases		
MG_Green	P X(4)	Aircraft tasking green number	Earmarks each task and conforms to operators system
MG_Month	P X(3)	Aircraft Green Month	Earmarks a unique green
MG_Acft	F X(6)	Military airframe designator	Identifies type of airframe that is performing task
MG_Green_Ex	F X(4)	Ex Green alignment	Allows dovetailing of tasks being performed by the same airframe
MG_Green_Ex_Mth	F X(3)	Ex Green month	Allows dovetailing of tasks performed by the same aircraft
MG_Green_To	F X(4)	To Green alignment	Allows dovetailing of tasks being performed by the same airframe
MG_Green_To_Mth	F X(3)	To Green month	Allows dovetailing of tasks performed by the same aircraft
MG_Change_No	D 9(2)	Last change number	Used in producing changes to aircraft greens.
MG_Date_Last_Changed	D D	Date task detail last changed	Used to determine which tasks require green changes to be output.
MG_Date_Of_Last_Change	D D	Date of last green change	Used to determine which tasks require green changes to be output. If<MG_Date_Last_Changed then output
MG_Status	D X(1)	Task status	Shows status of all greens generated
MG_Title	D X(40)	Task title	Used as a field on the aircraft tasking (green)

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RMHoursA	Entity Location: (Global or Operation Specific): 0	
Entity Description:	Actual Military Hours Flown		
Entity Purpose:	Maintains monthly statistics of actual hours flown		
MH_Acft	P X(6)	Military airframe designator	Identifies the type and rig of aircraft actual hours. Allows hours to be kept for specific rig and general type
MH_Month	P X(3)	Actual month flown	Month that actual flying occurred
MH_Amount_Hours	D 9(3)V9	Actual hours flown for month	Hours flown by a certain type and rig during the month

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RMNarrat	Entity Location: (Global or Operation Specific): O	
Entity Description:	Green Narrative for Mil Tasks		
Entity Purpose:	Records narrative comments for greens for military lift		
MN_Green	P X(4)	Aircraft tasking Green number	Used to link narrative comments on green to task(not a unique key as many narratives per green allowed)
MN_Month	P X(3)	Aircraft tasking month	Used to link narrative comments on green to task
MN_Sequence	P X(1)	Narrative sequence	Used to uniquely key narrative comments to a green
MN_Narrative	D X(150)	Narrative comment	Used to maintain narrative comments for each green

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RMTasks	Entity Location: (Global or Operation Specific): O	
Entity Description:	Military Task Flight Legs		
Entity Purpose:	Maintains task leg and green data for military tasks		
MT_From_Seq	P X(1)	Departure sequence	Allows payload to be tied to a leg, even if task flies the same departure/dest more than once
MT_Green	P X(4)	Aircraft green number	Ties flight legs to parent green
MT_Month	P X(3)	Aircraft tasking month	Ties flight legs to parent green
MT_Actual_Hours	D 9(2)V9	Actual leg hours	Compiles actual hours usage statistics
MT_DClose	D X(8)	Doors close month/day/time	Maintains start time of flight leg, in zulu time
MT_DC_DOW	D X(3)	Local DOW of doors close	Allows operator to readily see local day of departures
MT_DC_Local	D X(8)	Local time of doors close	Allows operator to readily see local time departures
MT_DOpen	D X(8)	Doors open month/day/time	Zulu time doors open.
MT_DO_DOW	D X(3)	Local DOW of doors open	Allows operator to readily see local day of arrivals
MT_DO_Local	D X(8)	Local time of doors open	Allows operator to readily see local time arrivals
MT_From	D X(5)	Departure airfield	Specifies leg data - from
MT_Hours_Code	D 9(3)	Hours code	Allows legs charged to other operations/activities to be included on operation tasks
MT_Lamp	D X(60)	Line amplification	Maintains line amplification data pertaining to task leg
MT_Mission	D X(15)	Mission statement	Specifies mission type
MT_Phase	D X(1)	Phase	Allows a task to perform tasks for more than one phase of the operation
MT_Rmks	D X(60)	Remarks line	Maintains remarks data pertaining to task legs
MT_To	D X(5)	Destination Airfield	Specifies leg data - to

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	ROHardA	Entity Location: (Global or Operation Specific): O	
Entity Description:	Hard initial C130 plot		
Entity Purpose:	Records date of lift and combinations of entities on C130 lift, using the hard resource algorithm		
OH_Combined	P X(4)	Serial controlling task	Provides basis for scheduling and routing of final plan. Null means the entity has sole use of the task.
OH_Date	P D	Date of C130 task	Provides basis for scheduling and routing of final plan
OH_Serial	P X(4)	Serial being uplift by C130	Allows a link between lift derived and Order of March data
OH_C130_Loads	D 9(2)	C130 loads tasked	Provides basis for scheduling and routing of final plan. Null means the entity is tasked with another serials task
OH_Prepositioned	D X(1)	Pre-position required	Provides basis for scheduling and routing of final plan. Null means the entity is tasked with another serials task

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	ROISoft	Entity Location: (Global or Operation Specific): O	
Entity Description:	Soft initial C130 plot		
Entity Purpose:	Records date of lift and combinations of entities on C130 lift, using the soft resource constraint algorithm		
OI_Combined	P X(4)	Serial controlling task	Provides basis for scheduling and routing of final plan. Null means the entity has sole use of the task.
OI_Date	P D	Date of C130 task	Provides basis for scheduling and routing of final plan
OI_Serial	P X(4)	Serial being uplift by C130	Allows a link between lift derived and Order of March data
OI_C130_Loads	D 9(2)	C130 loads tasked	Provides basis for scheduling and routing of final plan. Null means the entity is tasked with another serials task
OI_Prepositioned	D X(1)	Pre-position required	Provides basis for scheduling and routing of final plan. Null means the entity is tasked with another serials task

Relation Attribute List

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	ROLoads	Entity Location: (Global or Operation Specific): O	
Entity Description:	Payloads for Flights		
Entity Purpose:	Maintains planned and actual payload for military and civil flights		
OL_Green	P X(4)	Aircraft tasking - civil or military	Links payload to carrying task (0-1999=military, 2000-3999=civ charter, 4000-6999=rpt)
OL_Month	P X(3)	Aircraft tasking month	Links payload to carrying task
OL_Sequence	P X(1)	Departure sequence	Ties payload to specific leg where duplicates exist
OL_Serial	P X(4)	Serial of unit lifted	Ties payload to an O of M entry, unit detail and gives unique payload entry
OL_To	P X(5)	Destination airfield	Ties payload to one or more flight legs
OL_Green_From	F X(4)	Green payload linked from	Links movement of payload where transhipment used
OL_Green_From Mth	F X(3)	Month series of green payload came from	Links movement of payload where transhipment used
OL_Green_To	F X(4)	Green payload linked to	Links movement of payload where transhipment used
OL_Green_To_Mth	F X(3)	Month series of green series going to	Links movement of payload where transhipment used
OL_Pax_Type	F X(1)	Passenger weight category	Allows specification of passengers according to different weight classes
OL_Payload_Share_Green	F X(4)	Payload sharing green	Allows grouping of payload. A combined weight and pax figure covers more than one flight
OL_Payload_Share_G_Mth	F X(3)	Payload sharing green's month	Uniquely identifies the green with the combined payload figure
OL_Actual_Remarks	D X(50)	Comments about actual lift	History comment of actual problems, delays or other issues
OL_Cargo_Actual	D 9(5)	Actual cargo wt moved	Part of actual lift data
OL_Gen_Comments	D X(15)	General freight comments	Allows specification of type, class or handling of general cargo
OL_Gen_Wt	D 9(6)	Payload - General freight	Part of total cargo weight calculation
OL_Haz_Comments	D X(15)	Hazardous comments	Allows specification of d/c or explo classes
OL_Haz_Wt	D 9(6)	Payload - Hazardous freight	Part of total cargo weight calculation
OL_Pax_Actual	D 9(3)	Actual passenger no.s moved	Part of actual lift data
OL_Pax_No	D 9(4)	Payload - Passengers	Specifies no. of passengers to be moved. Large value range allows one payload line to cover many flights
OL_Remarks	D X(30)	General payload remarks	Allows comments about the payload to be moved ie not specific to a cargo class
OL_Sub_Unit_Detail	D X(10)	Sub-unit composition	Allows the plan to reflect lift to sub-unit level if required

Entity Title: ROMarOrd Entity Location: (Global or Operation Specific): O
Entity Description: Order of March
Entity Purpose: Ties units to serials and stores original lift requirement

Attribute Name	Dep/Format	Full Title	Purpose
OM_Serial	P X(4)	Serial Number	Keys planned and actual lift back to the order of march requirement
OM_Gen_Lf_Fact	F X(1)	Pounds to linear foot conversion factor-Gen	Allows aircraft loads required to meet lift to be estimated. Derived from RGFretWt
OM_Haz_Lf_Fact	F X(1)	Pounds to linear foot conversion factor-Haz	Allows aircraft loads required to meet lift to be estimated. Derived from RGFretWt
OM_Gen_Wt	D 9(7)	Total general cargo weight	Part of total lift requirement. Weight to cube conversion applied for general cargo
OM_Haz_Wt	D 9(7)	Total hazardous cargo weight	Part of total lift requirement. Separate hazardous weight to cube factor applied
OM_Loc_From	D X(5)	Departure airfield	Shows destination of lift requirement
OM_Loc_To	D X(5)	Destination airfield	Shows destination of lift requirement
OM_Move_Earliest	D D	Earliest date can move	Defines the front end of the available window for movement
OM_Move_Latest	D D	Latest date can move	Specifies the back end of the movement window. (Also equals the last day unit can arrive at destination airfield)
OM_Pax_No_Reservists	D 9(4)	Total reserve passengers	Allows quick recognition of passengers with strict timeframes for movement
OM_Pax_No_Total	D 9(4)	Total passengers	Provides part of the requirement for the serial. Equal full time + reserve passenger no's
OM_Phase	D X(1)	Operation phase	Allows deployment to be differentiated from redeployment ie plan only deploy and wait till later for redeploy
OM_Priority	D 9(1)	Assigned lift priority	Allows router and schedular to order requirements based on priority
OM_Sub_Unit_Alias	D X(15)	Sub-unit name	Allows better info on lift unit and allows alias for unit placed under command
OM_Unit	D X(15)	Recognised unit abbreviation	Keys into unit detail for Order of March
OM_Wh_A_No	D 9(2)	Type A vehicles	Allows cube for wheeled cargo to be derived, using an average length for A vehicles
OM_Wh_B_No	D 9(2)	Type B vehicles	Allows cube for wheeled cargo to be derived, using an average length for B vehicles
OM_Wh_C_No	D 9(2)	Type C Vehicles	Allows cube for wheeled cargo to be derived, using an average length for C vehicles
OM_Wh_Wt	D 9(8)	Total vehicle weight	Part of total lift requirement. Cube factor derived from class breakdown
OM_W_Tl_A_No	D 9(2)	Type A trailers	Allows cube for wheeled cargo to be derived, using an average length for A trailers
OM_W_Tl_B_No	D 9(2)	Type B trailers	Allows cube for wheeled cargo to be derived, using an average length for B trailers

Relation Attribute List

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	ROLoads	Entity Location: (Global or Operation Specific): O	
Entity Description:	Payloads for Flights		
Entity Purpose:	Maintains planned and actual payload for military and civil flights		
OL_Wh_Comments	D X(15)	Wheeled freight comments	Allows specification of wheeled cargo types eg 2xLDR 2xTLR
OL_Wh_Wt	D 9(7)	Payload - Wheeled cargo	Part of total cargo weight calculation

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	ROMarOrd	Entity Location: (Global or Operation Specific): O	
Entity Description:	Order of March		
Entity Purpose:	Ties units to serials and stores original lift requirement		
OM_W_Tl_C_No	D 9(2)	Type C trailers	Allows cube for wheeled cargo to be derived, using an average length for C trailers

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	ROOUsers	Entity Location: (Global or Operation Specific): O	
Entity Description:	Operation Users Statistics		
Entity Purpose:	Records actions of system users for each operation		
OO_User_Code	P 9(2)	User code	Key for statistics on logins, time and transactions per user per operation
OO_Logins	D 9(4)	RAPS active log ins per user	Statistics on frequency of logins
OO_Time_On	D 9(4)	RAPS hours per user	Statistics of hours spent managing the operation
OO_Transactions	D 9(3)	RAPS transactions per user	Statistics of transactions required to manage the operation

Relation Attribute List

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	ROPCDate	Entity Location: (Global or Operation Specific): O	
Entity Description:	Payload Changes by Time		
Entity Purpose:	Keeps counts of payload changes tracked against time till lift occurs		
OP_Carrier	P X(1)	Airlift carrier	Allows payload changes to be tied to carrier
OP_Phase	P X(1)	Operation phase	Allows payload changes to be tied to phase
OP_24hrs	D 9(4)	Payload changes within 24 hours of lift	Allows collection of numbers and timing of payload changes during an operation
OP_3days	D 9(4)	Payload changes within 3 days of lift	Allows collection of numbers and timing of payload changes during an operation
OP_6days	D 9(4)	Payload changes within 6 days of lift	Allows collection of numbers and timing of payload changes during an operation
OP_9days	D 9(4)	Payload changes within 9 days of lift	Allows collection of numbers and timing of payload changes during an operation
OP_Moredays	D 9(4)	Payload changes in excess of 9 days of lift	Allows collection of numbers and timing of payload changes during an operation

Relation Attribute List

Entity Title: ROR&Sch Entity Location: (Global or Operation Specific): O
Entity Description: Initial Routing Loads
Entity Purpose: Assigns the order of march to loads and aircraft type

Attribute Name	Dep/Format	Full Title	Purpose
OR_Serial	P X(4)	Order of March Serial	Allows a link between loads derived and Order of March Data for an entity
OR_B707_Gen	D 9(6)	General cargo earmarked to B707s	Provides a bound on what payload the router and schedular must met with C130s
OR_B707_Haz	D 9(6)	Hazardous cargo earmarked to B707s	Provides a bound on what payload the router and schedular must met with C130s
OR_B707_Pax	D 9(4)	Passengers earmarked to B707s	Provides a bound on what payload the router and schedular must met with C130s
OR_B707_Wh	D 9(6)	Wheeled cargo earmarked to B707s	Provides a bound on what payload the router and schedular must met with C130s
OR_C130_Loads	D 9(2)V9	No. of C130 loads required	Provides the raw input of C130 loads required for the router and schedular
OR_Civil_Gen	D 9(6)	General freight earmarked to civil charter/RPT	Provides a bound on what payload the router and schedular must met with C130s
OR_Civil_Haz	D 9(6)	Hazardous freight earmarked to civil charter/RPT	Provides a bound on what payload the router and schedular must met with C130s
OR_Civil_Pax	D 9(4)	Passengers earmarked to civil charter/RPT	Provides a bound on what payload the router and schedular must met with C130s
OR_Civil_Wh	D 9(6)	Wheeled freight earmarked to civil charter/RPT	Provides a bound on what payload the router and schedular must met with C130s
OR_Other_Gen	D 9(6)	General Freight earmarked to other military means	Provides a bound on what payload the router and schedular must met with C130s
OR_Other_Haz	D 9(6)	Hazardous freight earmarked to other military means	Provides a bound on what payload the router and schedular must met with C130s
OR_Other_Pax	D 9(4)	Passengers earmarked to other military means	Provides a bound on what payload the router and schedular must met with C130s
OR_Other_Wh	D 9(6)	Wheeled freight earmarked to other military means	Provides a bound on what payload the router and schedular must met with C130s
OR_Remarks	D X(20)	Load allocation remarks	Gives reasons for decisions or supporting data

Attribute Name	Dep/Format	Full Title	Purpose

Entity Title: ROTkLock Entity Location: (Global or Operation Specific): O
Entity Description: Operations Level Task Locking
Entity Purpose: Maintains locked tasks within each operation

Attribute Name	Dep/Format	Full Title	Purpose
OT_Key	P X(7)	Task being locked	Allows the green detail, narrative, task leg and load detail to be locked for a military, charter or RPT task
OT_User	F X(7)	User id of operator holding lock	Allows the system and other users to identify who has locked the task

Attribute Name	Dep/Format	Full Title	Purpose

Entity Title: ROUnits Entity Location: (Global or Operation Specific): O
Entity Description: Operation unit data override
Entity Purpose: Maintains temporary unit detail. Data in this relation overrides entries in the global relation RGUnits.

Attribute Name	Dep/Format	Full Title	Purpose
OU_Unit	P X(15)	Recognised temporary unit abbreviation	Used to tie payload to a unit's detail when normal unit detail has been changed for operation eg been placed unit different command
OU_Msg_Address	D X(20)	Temporary unit address for unit	Used to address messages to units relocated during operation
OU_MSg_For	D X(30)	Distribution for message at destination	Allows distribution field on aircraft taskings
OU_Title	D X(35)	Temporary unit title	Used to address and head reports where unit detail has been changed for the duration of the operation

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RPGreens	Entity Location: (Global or Operation Specific): O	
Entity Description:	RPT Tasks		
Entity Purpose:	Maintains headers for regular public transport airlift for all phases		
PG_Green	P 9(3)	Military airlift tracking green	Allows a unique and firm reference to a RPT flight in absence of a natural key
PG_Month	P 9(2)	Month series of tracking green	Provides a unique key to the RPT flight
PG_Green_Ex	F 9(3)	Military airlift tracking green for ex-flight	Allows flow detail of RPT tasks to be maintained
PG_Green_Ex_Mth	F 9(2)	Military airlift tracking green's month series	Allows key to unique ex-flight data
PG_Green_To	F 9(3)	Military airlift tracking green for to-flight	Allows flow detail of RPT tasks to be maintained
PG_Green_To_Mth	F 9(2)	Military airlift tracking green's month series	Allows key to unique to-flight data
PG_Remarks	D X(20)	General RPT remarks	Information about the task

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RPTasks	Entity Location: (Global or Operation Specific): O	
Entity Description:	RPT Flight Legs		
Entity Purpose:	Maintains task leg and green data for regular public transport flights		
PT_From	P X(5)	Departure location for flight leg	Provides key to departure location relation
PT_Green_Rpt	P 9(3)	RPT green	Provides a key for RPT flights in absence of standard and unique RPT flight numbers
PT_Green_RPT_Month	P 9(2)	Month of RPT green series	Allows a unique key to green for RPT
PT_To	F X(5)	Destination location for flight leg	Provides key to destination location
PT_Civil_Rego	D X(10)	Civil operator's flight number	Allows flight data to be tied to civil operator's reference
PT_DClose	D 9(6)	Doors close day/time	Define flight times
PT_DClose_Mth	D 9(2)	Doors close month	Gives the doors close month
PT_DOpen	D 9(6)	Door open day/time	Provides flight leg data
PT_Phase	D X(1)	Phase	Allows airlift to be traced by phase
PT_Remarks	D X(20)	RPT remarks	Allows information peculiar to the RPT task to be specified
PT_Seats_Booked	D 9(2)	Total seats booked	Allows actual bookings to tracked and commitment recorded

Relation Attribute List

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RQGreens	Entity Location: (Global or Operation Specific): O	
Entity Description:	Civil Charter Tasks		
Entity Purpose:	Maintains headers for civil charter airlift for all phases		
QG_Green	P 9(3)	Military airlift tracking number	Allows a unique and firm reference to a charter flight in absence of a key
QG_Month	P 9(2)	Month series of tracking green	Provide a unique key to civil charter flights
QG_Green_Ex	F 9(3)	Military airlift tracking number for ex-flight	Allow flow detail of aircraft to be maintained
QG_Green_Ex_Mth	F 9(2)	Month series of ex-flight's tracking green	Allow key to unique ex-flight data
QG_Green_To	F 9(3)	Military airlift tracking number for to-flight	Allows flow detail of aircraft to be maintained
QG_Green_To_Mth	F 9(2)	Month series of to-flight's tracking green	Allows key to unique to flight data
QG_Acft_Type	D X(8)	Civil aircraft type	Indicate the type of aircraft, not related to RGAcft
QG_Remarks	D X(20)	General charter remarks	Allows civil related information to be included
QG_Status	D X(1)	Status of flight	Allows all tasks to be recorded and stage known

Relation Attribute List

Attribute Name	Dep/Format	Full Title	Purpose
Entity Title:	RQTasks	Entity Location: (Global or Operation Specific): O	
Entity Description:	Civil Charter Flight Legs		
Entity Purpose:	Maintains task leg and green data for civil charter flights		
QT_From	P X(5)	Departure location for flight leg	Provides key to departure location relation
QT_From_Seq	P X(1)	Departure location sequence	Ties the payload to a unique flight leg, even when the same leg is flown a number of times
QT_Green_Civil	P 9(3)	Civil charter green	Provide a key for civil charter flights in absence of standard and unique series for civil flights
QT_Green_Civil_Month	P 9(2)	Month of civil green series	Allows unique key to green no for civil charter
QT_To	F X(5)	Destination location for flight leg	Provides key to destination location relation
QT_Civil_Rego	D X(10)	Civil operator's flight number	Allows flight data to be tied to civil operators references
QT_DClose	D 9(6)	Doors close day/time	Define flight times
QT_DClose_Mth	D 9(2)	Doors close month	Gives the doors close month (it may differ to the green's month)
QT_DOpen	D 9(6)	Doors open day/time	Provides flight leg data
QT_Phase	D X(1)	Phase	Allows airlift to be traced to phases, down to flight leg. A task may share phase activities eg Deploy and Maint
QT_Remarks	D X(20)	Civil charter remarks	Allows information peculiar to the civil task to be specified
QT_Total_Seats_Avail	D 9(3)	Total seats chartered	Specifies the maximum capacity of the civil aircraft

Appendix H: RAAF Airlift Planning System Increment Two Router and Schedular

Overview

This appendix discusses the static router and schedular component of RAPS. After describing the complete RAAF strategic operational airlift scheduling problem, a constrained problem, that is more readily solved, is defined.

Next, the component's role and applicability, inputs and outputs are considered. A detailed discussion of the procedures follows, including feasible versus infeasible plans and operator interaction. A description of matching algorithms completes the appendix.

Characteristics of Global Routing and Scheduling Problem

This section describes the routing and scheduling problem for the complete RAAF Airlift planning environment. The problem is defined according to a routing and scheduling problem classification, defined by Bodin, Golden, Assad and Ball in their 1983 paper (Bodin et al., 1983:73).

Routing and scheduling involves those activities to formulate a plan to met lift requirements with constrained resources. Inputs to the process are statements of the scenario, lift requirement and resources. Activities commence upon receipt of these inputs and continue until all the airlift plan meets requirements of the scenario and lift requirement.

Summary of Problem

The RAAF Airlift planning problem involves temporal and spatial considerations. Demand, in lift requirement must be met by a limited

fleet of aircraft. Limits are imposed on service time. Outputs of the planning process include a schedule of airlift and advice of cost of compliance and shortfalls in customer service.

The ranking in importance of time and space varies across scenarios. Consequently, scenario definition can cause the planning of airlift to adopt a form ranging from pure scheduling to pure routing. Normally, there exists a mix of time and space considerations, with time expected to be the most constraining resource.

Global Problem Characteristics

1. Size of Available Fleet: Multiple vehicles.

2. Type of Available Fleet: Heterogeneous vehicles.

RAAF strategic transport aircraft types include the Lockheed C130E and C130H and the Boeing B707. C130s are the predominant vehicle for the operational airlift planner. In their strategic airlift role, the two types of C130 have few differences in airlift characteristics of payload, speed and duration. Hence, all C130s are assumed to be homogeneous or consistent in characteristics.

Civil aircraft and the B707 are the other vehicle types available to the airlift planner. Availability of both types is tightly constrained as there are few assets, their high profile is often disadvantageous and their role restricted. The hire of civil aircraft is a deliberate and long range action, usually done before detailed airlift planning. Application of the civil and B707 aircraft is easily identified due to their small numbers and narrow role. However, their tasking affects C130 tasking by constraining ramp capacities and turn around.

The various configurations of the C130 can be changed enroute. Unfortunately, the same flexibility is not available with the B707. Each configuration of the B707 is considered as a different aircraft type during planning i.e. an "all pax" rigged aircraft is different to a "4/94" rigged aircraft.

3. Housing of Vehicles: Single depot.

Transport aircraft operate out of one base, RAAF Richmond, NSW. Occasionally, aircraft and their maintenance staff are temporarily located to another base in support of an exercise. The single depot concept remains, with the depot being the temporarily deployed location. A mix of vehicles from a temporary and the main depot for an operation is unusual.

4. Nature of Demands: Deterministic.

Demand at nodes is known in advance, through a requirement or Order of March. Because demand is known in advance, stochastic estimation is not required.

Demand is presented in two ways. At the beginning of the planning operation, demand is grouped and presented to the planner as an Order of March. This document lists all demand entities. An entity is the smallest organisation that can be treated as one item by movement planners. For each entity, data is provided on size, departure and destination locations, precedence and time windows required for service. Demand in this form can be considered static to the planner.

Demand also can be presented after initial planning. Then, it is presented as an additional requirement and amendment to the Order of March. In this form, demand adopts a more dynamic form.

5. Location of Demand: At Nodes, not necessarily all.

Demand is at departure airfields. Though entities are often not permanently housed at an airfield location, they have been pre-assigned to airfields. The movement of forces to and from a point of embarkation is not a RAAF planning responsibility.

6. Underlying Network: An Undirected Euclidean Network.

If network cost is a factor of distance, the network is Euclidean. This means that the distance function satisfies the triangle inequality requirement that the direct path between two points can be no longer than the indirect path between points.

The significant effect of wind on aircraft speed and hence distance covered suggests that aircraft routes are directed and may not be euclidean. Often, because the effect of wind is unpredictable, its affect is largely ignored when planning airlift. When applied, wind affect is incorporated at implementation of airlift.

If the effect of wind on the network and routing is ignored, then cost, based on distance and time, is independent of the direction between two points.

7. Vehicle Capacity Restrictions: Imposed and different.

Aircraft load capacities are based on many factors. The payload availability is the maximum payload weight that the aircraft can carry on a task leg. Payload is also constrained by volume, based on inside cargo compartment dimensions for the aircraft types. Volume maximums are consistent across all airframes of each type of aircraft in the fleet.

Payload weight limits vary for each leg of a task. A task leg includes taxi, take-off, flight between two airfields, landing and taxi.

Many flight legs may form a task or mission. A task is a sequence of continuous legs assigned to an airframe. This assignment may involve aircrew and an airframe type, though this is not necessary.

Each aircraft type has different maximum take-off and landing weight limits. Though airframes differ in weight, the planner considers maximum payload availability for all airframes of a type to be the same. Maximum payload is the maximum landing weight less the aircraft's dry operating weight.

To calculate the payload availability for a task leg, weight requirements for fuel, crew and maintenance spares are subtracted from the maximum availability. As fuel weight is based on flight time between refuels, the remaining payload availability becomes dependent on distance between refuel points. This distance is usually the leg distance, as refuel is offered at most airfields. However, some airfields or scenarios do not allow for refuel at a destination. Additionally, some airfields require aircraft operations at less than maximum weight. These airfields are typically less busy and the C130 is the normal aircraft restricted.

Although weight limits may restrict C130 operations at some airfields, all airfields nominated as departure or destination airfields are C130 capable. Airfields do not have to be B707 or civilian aircraft capable. Most airfields restrict the number of aircraft on ground at any time by way of ramp limits.

8. <u>Maximum Route Times</u>: Imposed and different across aircraft types.

Maximum route times constrain flexibility in tasking aircraft. The planner encounters four types of route time limitation, including

aircrew, aircraft maintenance, aircraft continuous tasking and delay enroute.

Safety regulations limit the maximum continuous time an aircrew can be tasked. That amount depends on the type of task and augmentation of the crew. Regulations also specify the minimum crew rest required between taskings. The type of task and maximum crew day remain constant for an operation. These values differ across aircraft types.

An aircraft's availability is limited by maintenance. Unservicibilities can be scheduled or unscheduled; unscheduled arisings are not predictable and are ignored at the planning stage, except for occasional tasking of "spare" aircraft. The planner determines spare aircraft requirements in cooperation with customers and operators. Spares are added to a schedule after all planning activity and affect ramp capacity.

Scheduled maintenance is of two types, major and minor. Minor servicing can be categorised by "on ramp" turnaround and major servicing by hangar turnaround. Only major scheduled servicing affect the planning for aircraft utilisation as minor servicing is performed during crew rest or turnaround periods. Where aircraft return to a depot (Richmond usually), scheduled servicing becomes transparent to the airlift planner. Maintenance planning staff arrange airframe replacement, ie the airlift planner does not plan down to specific airframe.

When absent from the depot for a period exceeding the time to next major servicing one of three things occurs. The airframe may be serviced remotely. If servicing at depot is required, airframes may be changed remotely with deadlegs not met by the operation. Lastly, the

airframe may return to the depot with deadlegs met by the operation. For the planner, servicing needs for an aircraft to return to depot are not usually considered. Still, the planner usually favours tasking with regular returns to depot. Definite return to depot requirements are often injected during implementation of an airlift schedule.

Aircrew availability affects airframe availability for tasking. An aircraft is not restricted to one crew, though only one crew can man the airframe at any time. Individual crew restrictions have already been addressed. Additional crews, called slip crews, are available at the depot or they can be pre-positioned en route. The application and positioning of slip crews is based on experience and operating squadron advice.

It is not unusual that aircraft and crew must wait en route for extended periods to meet pick-ups that are restrained by availability windows. While waiting, crew and aircraft are effectively removed from the resource pool available to ALG. Planners endeavour to minimise the time aircraft and crews spend waiting en route. The maximum delay en route is usually limited to two days, though more realistic wait limits are based on flying time between departure and depot airfields.

9. <u>Operations</u>: Mixed pick-ups and deliveries with split consignments.

Airlift involves the pick-up of demand from nodes or airfields and its delivery to other nodes. An aircraft task leg may lift only part of the demand at a node.

Where splitting of pick-ups and deliveries is considered, the order of march or task may dictate a maximum window for consolidation. For example, a window for movement may dictate earliest time an entity is available to move or the latest time by which the entity must have

moved. Consolidating or grouping of entities is permitted. For personnel and some types of freight, severe limits are placed on time in transit. Transhipment is also permitted. Flexibility to consolidate and tranship is restricted by scenarios and requirements of the Order of March. In fact, consolidation and transhipment is unusual in airlift operations. These concepts are more applicable to routine maintenance operations, which fall outside the scope of this system.

10. Costs: Routing costs.

Accurate costing of military airlift is difficult. Though it appears that airlift costs can easily be split between fixed and variable operating costs, this is not so as costing principles remain confused. Guidance from senior management concerning the cost of airlift is still required and expected as a product of the adoption by the ADF of Program Management and Budgeting. Examples of "grey costs" include the application of costs of training, salaries for crews and costs of fuel and services from RAAF, other military and civil airfields.

It is normal for costs to be expressed in units of flying hours by aircraft type. As flying hours are a factor of distance and speed for each aircraft type, this measure has a near-linear relationship with distance covered. Thus, current systems cost according to variable routing costs. Fixed or overhead costs, normally included in fleet operations planning, are not considered.

However, the defining of resources constraints in terms of flying hours introduces inaccuracies. It limits solution alternatives and often pre-determines solutions by defining utilisation rates for each aircraft type. Despite management's wish to define resources limits in

terms of variable routing costs, units of measurement should allow planner flexibility.

Other civilian and military transportation agencies have had considerable success with the application of dollar limits on resources. Where dollar cost was difficult to determine or organisations wished to introduce weighting for other than actual cost, systems using management defined generic units have been applied. Under this approach, executive management defines the generic worth of each flying hour of each aircraft type. Resources available to planners are then expressed in these generic units, for example Air Transport Units. This approach maintains planner flexibility and encourages rigorous comparisons of aircraft types to find the best types for each task.

Despite the inaccuracies the flying hour resource allocation approach introduces, the RAAF uses it. Its supporters claim it is a simple way of limiting over commitment of airframe types. As ADF higher management allocates ALG its resources in terms of flying hours per airframe type, limits are simply derived from executive allocations. Additionally, it avoids issues connected with the accurate costing of airlift that remain unresolved.

11. <u>Objectives</u>: Minimise total routing costs and fleet size.

When planning airlift, there can be one of two objectives. The first is the meeting of the lift requirements with the least cost, in terms of flying hours. The other concerns minimising airframes committed. These two objectives may not produce the same results.

Planners usually overcome this problem by predetermining the fleet size before planning or by having available fleet size presented to them. They then plan with an objective of minimising flying hours. If

the Order of March cannot be met with the allocated fleet size, the fleet limits are eased and planning reapplied.

Characteristics of Relaxed Routing and Scheduling System

This section describes a sub-set of the RAAF airlift planning problem. The relaxed problem lends itself better to computer based solution techniques.

The RAAF airlift planning problem of matching lift requirements against airlift resources in the presence of temporal and spatial considerations is a hard problem.

The problem is hard according to the mathematical definition of problem complexity when related to time and space requirements to solve optimally. It is hard in the sense of not having precise definitions of objectives. It is also hard because of the non-linearity of many constraints. Research into similar problem found the capture of all binding constraints involved in these types of problems is itself a large task (Bodin et al., 1983:184).

The present manual planning approaches attempt to solve the routing and scheduling problem by not seeking optimality and by relaxing constraints. Planners seek feasibility and not optimisation by restricting alternatives, applying heuristic methods and relying on past solutions as indicators of successful solutions. Constraints are relaxed by making them linear or not considering them until plan implementation. Planner also apply their own perceptions of airlift objectives. Having found feasibility, planners may then choose to improve planning while remaining feasible.

The aim of problem relaxation is to decompose an original problem in such a way to deduce a problem that is easier and yet is an accurate representation of the original problem. The solution of the relaxed problem should greatly contribute towards the solution of the original problem.

In looking for a problem that allows computer assisted solution techniques, two considerations exist. The first is to define a problem in a way that the environment can be analysed by a computer based system. The other is to reduce the time and space requirements of solution techniques. Essentially, a logical fence needs to be erected around the problem to make it both definable and do-able by a computer based system.

Relaxed Problem Characteristics

1. Size of Available Fleet: Multiple vehicles, numbering between one and fifteen.

The RAAF has 24 C130s. Of this number, between four and six are normally undergoing scheduled and unscheduled maintenance at any time. Exercise Kangaroo '89, which was described as the biggest strategic airlift since World War II, used no more than 14 airframes on any day (Air Lift Group, 1989: Attachment A to Appendix 2A to Annex A).

2. Type of Available Fleet: Homogeneous vehicle - the C130.

For the planner, application of the civil and B707 aircraft is easily identified due to their small numbers, narrow role and limited routes. Yet, for an automated system, their routing and scheduling causes considerable increases in system complexity. For example, B707 and civil aircraft cannot be considered to be homogeneous as they have different configurations that cannot be changed on-route. Additionally,

they have more constraints on their operations, of which many are non-linear.

In essence, the majority of the planning activity for strategic airlift involves the C130 aircraft. This is in terms of both time taken to plan, flexibility achieved and proportion of plan tasked to the C130. In line with the overall methodology of evolutionary design based on most return for investment, the routing and scheduling of B707 and civil aircraft will be not be automated.

B707 and civilian leased aircraft tasking will be planned by the airlift planner. Their planned tasking will be stored by the information system. This allows B707 and civilian tasking to be incorporated in planning output. The routing and scheduling system will consider their presence when considering ramp capacities and turn-around for C130 aircraft. The proofing sub-system will examine flying times, route duration, load capacity and airfield ramp capacity of all aircraft types. Finally, cost and hours statistics will include non-C130 measurements.

3. <u>Housing of Vehicles</u>: Single depot.

4. <u>Nature of Demands</u>: Deterministic.

Demand is in the form of a "bill" or lift requirement. This bill is expressed in numbers of personnel and pounds or tonnes of cargo. Cargo type is identified to assist in matching loads to fill aircraft and avoid incompatibilities, for example explosives and personnel. The bill is advised through a statement of requirement called an order of march.

Demand is deterministic as it is not estimated by empirical demand or a probability distribution function. However, demand is both static

and dynamic. Static demand is advised by the order of march prior to planning of airlift. Dynamic demand is presented as amendments to the order of march, or as new requirements, an occurs after planning has started.

5. Location of Demand: At Nodes, not necessarily all.

Nodes are airfields capable of supporting strategic aircraft. Nodes do not have to support all aircraft types and may restrict capacity or endurance of aircraft and the maximum aircraft on ground at any time. Demand destination is other nodes in the network.

Nodes are identified for the planner and there is little flexibility to change demand or destination locations. Based on Exercise Kangaroo '89 data, a maximum of 15 demand nodes and 5 destination nodes or vice versa are necessary (ie 15 demand/ 8 destination or 8 demand/ 15 destination).

6. Underlying Network: An directed Euclidean Network.

A euclidean network is one which obeys the triangle inequality ie the hypotenuse can be no longer than the sum of two sides of the triangle. Arcs distances will be calculated from the grid coordinates of the departure and destination nodes.

Large scale and general effect of weather will be incorporated when routing and scheduling.

7. Vehicle Capacity Restrictions: Imposed and the same.

One generic aircraft type is considered and the capacity of this type (C130) is homogeneous across the fleet. However, aircraft capacity for each arc may vary and is a function of leg distance to next available refuel and characteristics of the departure and destination airfields.

8. Maximum Route Times: Imposed and the same.

There are three considerations that concern the planner in relation to limits of route times; continuous crew tasking, continuous airframe tasking and continuous period an airframe is away from depot.

Safety regulations limit the maximum continuous time an aircrew can be tasked. That amount depends on the type of task and augmentation of the crew. Regulations also specify the minimum crew rest required between tasking. Crew augmentation will not be considered by the routing and scheduling system, though the operator may modify the produced plan to include crew augmentation.

As the type of task is reasonably constant for an exercise, maximum crew day and rest will be specified by the planner and observed by the routing and scheduling system. Because crew duty and not crew rest allows for before flight and after flight servicing, crew specifications supplied by the operator will be defined in terms of time allowed for pre-flight activity, time allowed to fly and time allowed for after fight activity.

Airframe availability is limited by maintenance. Unscheduled arisings are not predictable and are ignored at the planning stage, except for the occasional tasking of "spare" aircraft. Spare aircraft will be determined by the planner and added to the schedule. The scheduling system will not consider spares except for checking ramp capacity limits.

Where aircraft return to the Depot (Richmond usually), scheduled servicings become transparent to the airlift planner. Airframe changes are managed by maintenance planners without affecting the number of

aircraft available. The planning system will not account for aircraft by tail number ie down to specific airframe.

When absent from the depot for a period exceeding time to next major servicing, an airframe may be able to be serviced remotely. Alternatively, an airframe change may be performed remotely with deadlegs not met by the exercise or the airframe recalled to the depot with deadlegs met by the exercise. Normally, airframe changes are transparent to an operation. Consequently, the scheduling system will not consider major servicing demands for an aircraft to return to depot. Flying hour costs of a return to depot will be assumed to be not met from operation allocation. However, the scheduling system should favour tasking with regular returns to depot. Definite return to depot requirements can be applied by the planner after initial planning.

Obviously, aircrew availability affects airframe availability to perform tasks. Though an aircraft is not restricted to one crew, only one crew can man the airframe at any time (including turnaround). Individual crew restrictions have already been addressed. Additional crews are available at the depot or they can be pre-positioned en route, otherwise caused slipping of crews.

An algorithm to calculate the most efficient distribution of crews would be complex. However, slip crew locating is a responsibility for squadrons operating aircraft. Hence, effort by the scheduling system to calculate slip crew distribution would be expensive in terms of time taken and design yet may not include all constraints that a squadron may consider necessary. Any planned distribution would be subject to squadron amendment. Therefore the application and distribution of slip crews will not be considered by the scheduling system. Better

performance would be achieved by planner input of slip crew usage based on experience and operating squadron advice.

The plan proofing sub-system will highlight excessive route timings based on minimum and single crewing. Therefore, application of augmented and slip crews will be highlighted to the planner. Routes found with excessive timings will still stand.

With the application of temporal constraints on uplift, the scheduling of aircraft becomes important. Where windows of demand availability are not matched, yet it is disadvantageous for the aircraft to return to depot in between pick-ups, some systems allow a vehicle to wait at a node for demand to become available. Though waiting should not be discounted in the planning of RAAF airlift, the cost of having an airframe idle and away from the depot must be considered.

As resources are provided in increments of flying hours and route cost will be based on distance covered, implementation of an accurate cost of waiting would be difficult. A more simple heuristic approach is to be used. Firstly, maximum delay at any node on a route is limited to two days. Airframes may wait enroute provided the cost to include legs to the depot and return later to the node are not less than four hours flying time per day waiting. Where crew rest must be taken at a node candidate for waiting, the period of crew rest is not included in the wait period.

9. <u>Operations</u>: Mixed pick-ups and deliveries with split consigning allowed.

With airlift, payload may be picked up from many nodes and delivered to other nodes en route. Consequently, mixed pick-ups and deliveries must be allowed, and the increase in algorithm complexity

accepted. Because it is not unusual for demand at a node to exceed aircraft capacity many times over, splitting of demand over many aircraft must be allowed. Where a split pick-up is considered, the Order of March should dictate the preferred split for each demand location. This will be achieved by specifying unit loads and for each unit comprising the demand at a node, if splitting of unit integrity is allowed, and if so what restrictions may be applied. Where splitting occurs, all pick-ups and deliveries must meet specified time windows.

Demand at a node may also be considerably less than an aircraft load. Consolidation is permitted and best applied to cargo. For personnel, limits are placed on time in transit and amount of extra travel undertaken. Though transhipment is allowed, excessive cost penalties apply where personnel must transit a way point overnight. Obviously, through the Order of March, a planner can specify if payload cannot be consolidated or transhipped.

10. Costs: Routing costs.

Costing of airlift is a necessary requirement of the system and the router and schedular should give some indication of the expected cost of a airlift operation. Unfortunately, accurate costing of military airlift is difficult. Though on the surface easily split between fixed and variable operating costs, guidance from senior management concerning the cost of airlift is still required. Examples of this include the cost of training, salaries for crews and fuel and services from RAAF, other military and civil airfields.

The RAAF has a fixed fleet size. Therefore, it would be normal for costs to be based on variable routing costs. As resources are provided in units of flying hours, costs will be calculated in units of

flying hours. Despite the inaccuracies this approach introduces, it is a reasonable approach as flying hours consumed is a factor of distance and input cruise speed for each aircraft type, providing a linear relationship to distance covered.

Different aircraft types have different operating costs for each flying hour. Though accurate hourly costs are difficult to derive, there are clear differences between operating costs of some types. As the routing and scheduling system examines one aircraft type, the C130, it can base its costing on flying hours. However, to provide information to a planner to allow him to best apply different airframe types, the proofing and checking component of the system will provide an approximate costing in dollars of the lift operation. As this system is applied after the routing and scheduling system and after the planner has applied planned airlift for other aircraft types, a good indicative costing can be provided. Costs will be based on the number of planned hours found by the proofing and checking system, for each aircraft type, multiplied by the operator specified per hour cost of each aircraft type.

11. Objectives: Minimise total routing costs.

Two conflicting yet possible objectives implies that separate routing and scheduling systems are required. Alternatively, one objective may be applied in all cases. The other objective could be applied as a constraint. As the minimisation of variable costs, ie hours consumed, while meeting requirements is the common objective, it will be applied.

However, the minimum application of airframes will also be supported interactively. To operate the routing and scheduling system,

the operator inputs the airframe allocation as either one figure per airframe type which is consistent across the airlift period or a daily availability for each type. By varying the maximum airframe allocation and disposition and re-running the router and schedular with these modified inputs, the planner can ascertain the change in airlift cost or duration caused by the change in allocation. Therefore, in the less common case where airframes committed or duration of lift must be minimised, the system will support location of feasible alternatives and assist in the ranking.

Static Router and Schedular

The static router and schedular is a component of the RAPS. Through interactive support and analysis, it helps an operator derive the first version of an airlift plan. After defining parameters that control matching and search sequences, the operator chooses methods to match lift requirements against resources. Matching commences and the operator is kept appraised of progress.

Matching only considers C130 aircraft. Best results occur when tne operator defines non-C130 activity before running the matching process.

During matching, operator input is sought. The operator makes decisions concerning control of analysis, such as the rejection of a lift request. The operator also adjudicates on issues of payload feasibility and manipulation of lift request time frames. Lastly, the router and schedular presents results to the operator and work can be either acceptance or rejected for further review.

Two heuristic matching methods are available. The operator may choose to apply any or all methods. After each process, the system will present results of the matching. Result statistics include expectations of:

1. plan feasibility,

2. flying hours required in weekly units,

3. aircraft required per day and indications of their utilisation,

4. payload expressed as grand and weekly totals and dissected into units of personnel and freight, and

5. Order of March entities moved on their preferred day, within their available window and outside their available window expressed as entity totals, payload totals and percentages.

This data gives good indication of cost of the plan, resource commitment and utilisation and customer satisfaction. Armed with this and the ability to closely scrutinise the draft plan produced by each method, the operator decides which method's result to adopt as the initial version of the operation's airlift plan.

Application

The component has application after detailed definition of scenario, resources available and lift requirement. Requirements are matched to resources in a heuristic fashion to derive a feasible plan that aims to meet lift windows and minimise resources committed.

Though intended to only be run once during an airlift operation, a planner may choose to run the static router and schedular many times. By tuning resource and requirement definitions after runs, an operator can derive a better starting plan.

The router and schedular only analyses requirements and resources. It is not responsible for compilation of data for an operation, relying on other system components to build and edit global and operation specific data.

Limitations

Heuristic Approach to Solution Generation

The routing and scheduling of limited airlift resources is a difficult problem. Mathematically, it falls into the hard category of operations research problems, meaning that it is computationally burdensome in both computer time and space.

When confronted with burdensome problems two options are available. First, given the time and computer power, optimal solutions can be generated, often by trial and error or systematic elimination of candidate solutions.

Alternatively, quicker methods, based on heuristic approaches, are applied. While generating solutions sooner, rule of thumb approaches have drawbacks. They do not guarantee optimality. Solution techniques often attempt to find an initial feasible solution. Improvements are attempted while maintaining feasibility. If some measure of the optimal solution is known, this approach probably could find it. However, this is not so with airlift planning as no guarantee of optimality is possible.

This should not be surprising to the airlift planner. Manual techniques apply much the same approach. Time dictates that only a small portion of possible solutions be considered for most problems. The narrowing of alternatives, though often intuitive, involves rule of thumb techniques based on experience.

The router and schedular applies heuristic techniques. Therefore, optimality can neither be guaranteed nor realised. Further, most objectives of airlift planning are qualitative, including issues such as fluidity, flexibility, responsiveness and usefulness. Quantitative models must be derived for them. This usually involves simplification of objectives which further reduces likelihood of finding optimality or even realising when optimality has been achieved.

However, heuristic methods do derive timely solutions to airlift routing and scheduling problems. Optimality too late is useless. Also, given the dynamic nature of airlift in operations, a priori optimality does not mean much. What is required is a good starting point. Heuristic methods, if applied properly, "can generate a 'good' solution rather quickly and the result provides significant improvement over trying to create a schedule manually" (Davis, M., 1988:132).

The router and schedular relies on three players. It harnesses the computers speed with simple and repetitive calculations. It relies on research and considered techniques, in computer code, to guide simple decision making. These players are subordinate to the operator, who makes executive decisions and applies real world considerations. Together, these players can produce a good initial airlift plan, given sufficient direction, data and time.

Effect of Scenario Upon Component Usefulness

Generally, the routing aspects of airlift planning lend themselves better to automation. Constraints and objectives tend to be more linear and quantitative, being concerned with issues of meeting demand and minimising distance covered. Scheduling aspects of airlift planning are

more qualitative and deal with issues of customer service and satisfaction.

The static router and schedular is best suited to an operation involving many departures and destinations. This situation provides many alternatives to mix airlift and requires many simple and repetitive computations. An operation with few departure and destination point, such as a round the clock logistics build-up or fly-in, usually involves the airlift planner in aspects of managing crew duty periods and detailed load planning. Because of their complexity and non-linearity, high level planning models are used to plan crew duty and loads.

Alternatively, the operator may choose to manually conceive the initial plan. This option suits small scale scenarios or operations involving rigid airlift commitment.

Limited Aircraft Type Consideration

Only the C130 aircraft type is considered in the automatic matching of requirements against resources. The C130 is the predominate airlift resource of the RAAF. Yet, it is not usually subject to strict directions concerning use. Most departure and destination airfields can accept the aircraft and minimal ground handling is required.

Conversely, the B707 and civil leased aircraft are often subject to a priori tasking. Additionally, there are many constraints on their operations, such as pavement restrictions, ground handling requirements and contractual obligations.

To automatically match these resources against requirements, complex methods would be required. Additionally, vast amounts of data would require input for each application. Yet gross simplifications

would still have to be applied. For results to be useful, significant operator input would be required.

Given the restrictions on non-C130 aircraft application and their minor role in most airlift operations, the operator could derive a concept of application without computer support. Consequently, the system concentrates on assisting operator tasking and maintenance of non-C130 airlift. Having decided how non-C130 airlift will be applied, the operator can use system functions to add and modify their tasking.

However, the router and schedular does acknowledge non-C130 tasking made before running the component. It reduces the Order of March lift requirement that it matches by that payload met by manually tasked aircraft.

Inputs

Inputs can be divide into three groups, environment, resources and lift. Input is provided in electronic form. Other components of RAPS, such as the global data building and major and minor database manipulation routines provide the support to build and present data. Alternatively, electronic data interchange conventions may allow data to be "imported" from other sources.

Environment Inputs

Environmental data is comprised of two groups. The first is data global to the airlift planning, including:

1. airfield data such as global location and limitations in pavement or parking.

2. aircraft characteristics including speed and endurance for C130 and non-C130 aircraft, and

3. aircrew day limits by airframe type.

The other group includes decisions and limits already in place for the operation. These include:

1. manually defined C130 partial and full loads,
2. manually defined non-C130 loads, and
3. home base airfield for C130s.

Lift Resource Inputs

Resource limits must be specified to the system, in terms of:

1. maximum airframes per day, by type allocated for the operation, and
2. total flying hours available by airframe type.

Lift Requirement Inputs

The prime document which specifies uplift or customer requirements is the Order of March. For each entity, the Order of March includes:

1. departure airfield,
2. destination airfield,
3. window where available for uplift,
4. preferred uplift day within window,
5. flexibility in uplift day indicator, and
6. relation to other Order of March entities and the specific relationship.

Outputs

The system outputs detailed and summary data. Detailed data is formatted as a draft plan, which other components of RAPS can access and manipulate. Summary data includes:

1. aircraft committed per day with maximum and minimum highlighted,
2. total payload moved,
3. number of entities lifted,

4. entities moved on their preferred lift day,

5. entities moved within their window but not on their preferred lift day,

6. entities struck from matching,

7. flying hours committed,

8. flying hours not committed, and

9. plan feasibility or infeasibility.

Besides being available in hard or printed form, output is produced in electronic form. This facilitates ready adoption by RAPS of a draft plan as the initial plan for an operation. Another component allows the draft to be adopted. Additionally, ready "export" to other computer applications results.

Each algorithm produces output. However, data is directed to different holding files, allowing the operator to review results of more than one algorithm before choosing one to adopt as an initial plan. Reruns of an algorithm will overwrite previous output from that algorithm for the operation, though the operator is given an option to move previous versions to other files.

Procedure

The system will first allow the operator to input planned commitment of non-C130 types and "must go in this form" C130 tasks. Remaining lift requirement will be matched by the system, using a heuristic routing and scheduling algorithm. Basic feasibility checks will be applied, including flight duration, adherence to windows for minimum flexibility entities and exceeding resources available. A plan, if feasible, will be presented to the operator.

No Feasible Plan

Where the system cannot meet the lift requirement with the resources allocated, no feasible plan can be formulated. Feasibility is a combination of meeting demand, within resources limits and within hard time limits. Inability to remain feasible and within movement windows will not usually cause plan infeasibility. The system considers windows of entities without the lowest flexibility indicator to be "soft". It will automatically relax these windows to find a feasible plan. Operator input will define the initial direction of relaxation ie move window forward or backward.

Because of the heuristic approach, no initial infeasibility does not mean that there is no possible solution. However, this is likely.

If no feasible initial plan can be located, the system will store the progress it made in planning the airlift. A suitable message is displayed, including a percentage indicator of the lift met before infeasibility. The operator can review the plan and provide remedial assistance. Assistance could take the form of more manual routing, an increase in resources or a reduction in requirement. Changes would be made to inputs or the overriding operator tasking, all of which will require electronic amendment. The remedial options either ease the constraints or guide the algorithm toward some preconceived notion of the solution.

Alternatively, the operator may signal acceptance of the progress made to date with planning, allowing the system to consider only that proportion of the inputs committed in the feasible plan. Upon acceptance, the system will consider process but only considering the partial case ie proofing will be performed even though the plan is

incomplete. The approach may be suitable where infeasibility was encountered with only few entities remaining to commit. Processing ordering should ensure these entities are the smallest and most marginally expensive to apply.

Feasible Plan

If a feasible plan is found, it is presented to the operator in electronic and summary form. The operator may print the report, study it and make overriding amendments to the electronic form of the plan. Upon signal to continue, the system will examine the electronic form of the plan, which may have been amended by the operator, and commence proofing it.

Insertion Algorithm - Sequential

The sequential insertion algorithm attempts to find a plan by maintaining feasibility. Airlift resources cannot be committed in excess of daily limits. After arranging Order of March entities by importance, the algorithm steps through each entity, assigning airlift to meet lift requirements. Uplift on the preferred day is first attempted, followed by the nearest day within each entity's uplift window. If lift cannot be met within the window, the operator can allow the window to be relaxed or the entity struck from the planning process.

Upon finalisation, the algorithm declares feasibility if all lift has either been assigned or struck from the assignment process. Infeasibility results when lift could not be assigned in a way to stay within airlift resource limits. Regardless of feasibility, supporting summary data and a detailed plan are presented upon completion. Should airlift resource limits be observed, the plan is declared feasible, regardless of lift of entities outside windows.

This algorithm is the "airlift provider's friend," keeping additional airlift resources at arms length. It has best application where airlift resource limits are firm. Always staying within daily airlift limits, this algorithm meets lift requirements in order of importance. The operator can choose to discard entities.

However, the algorithm is prone to bogging down when the Order of March requires surges in airlift. Though excessive tasking for short periods may be acceptable to management, the algorithm stubbornly considers airlift limits as firm.

Order of March entities are first arranged by flexibility indicator and the size of lift to gain relative significance. Each entity is then considered for uplift on its preferred day.

Uplift of the whole entity on an existing task leg with sufficient spare capacity is considered where lift-yet-to-be-met is less than an aircraft load. Otherwise, additional airlift resources are committed, if available. If not available, additional tasking of existing airlift is considered, though all lift must occur on the preferred day. If still unable to met lift, attempts are made to spread the requirement across more than one existing task.

Allocation of lift to met requirements is performed in increments of up to one aircraft load. Where an entity requires more than one aircraft's commitment, the lift allocation sequence considers one aircraft lots. After an allocation, residue lift-yet-to-be-met is then resubjected to the complete allocation process.

Where lift cannot be met on the preferred day, the system examines other days within the lift window, seeking the closest day. Though the

full window is considered, operator definition of direction of search affects search order.

If lift still cannot be met, operator advice is sought. Options allow expansion of windows in defined directions, the striking of entities from the process or halting of algorithm processing.

Where part of an entity's lift requirement remains not met and a shift in day is needed, that portion already met on the day remains met on that day.

Detailed Algorithm

Control

1. Order entities by ascending flexibility indicator and then by descending size of lift.

2. Take the next entity in order. If none remain, go to finalisation (step 15). Otherwise, assign the lift day as the preferred lift day and set lift-yet-to-be-met to the lift required.

3. Perform allocation (steps 8 through 14), using the defined lift day. If all lift is met go to step 2.

4. If the entity has the lowest flexibility indicator go to step 6. If the entity's day of lift can move in the direction defined by the operator and remain within the allowed window, set lift day to the nearest day in the defined direction and within the window and go to step 3.

5. If the entity's day of lift move any direction and remain within the allowed window, set lift day to the nearest day that is within the window and go to step 3.

6. Advise the operator that lift cannot be met within the available window or because of low flexibility. Three options are presented to the operator:

(i) Halt processing, record the plan as infeasible and go to finalisation (step 15). This option would be taken when the operator senses that, under this algorithm, the Order of March clearly cannot be met by the airlift resources. The matching would be terminated, the plan as infeasible and summary statistics finalised.

(ii) Strike entity from the matching and go to step 2. This option allows all or part of the entity to be struck from the algorithm. This allows the operator to maintain the entity's

lift, flexibility indicator and window. The operator may be prepared to task aircraft above the defined maximum per day or review the situation once other entities are tasked. Essentially, this option means "Don't worry about it; I'll do it myself!". The operator can choose to eliminate all of the entity or only that part of the entity's lift that remains not met.

(iii) Expand the entity's window until lift is met and go to step 3. This option allows amending of defined lift window, implying softness into window restrictions.

Considering the operator globally defined preferred direction of window relaxation, the system either expands only in the stated direction or in both directions, starting with the preferred direction. Thus, the planned day of lift for the entity will move in the defined direction to that day closest to the window where lift can be met.

Having selected a new lift day, go to step 3. A safety bound will limit the maximum number of days an entity's window can expand. If the bound is reached, go to step 6 (this step again) but restrict options only to halting processing or striking the entity.

7. Go to step 2.

Allocation

8. If the lift-yet-to-be-met is one aircraft load or more go to step 10 otherwise go to step 9.

9. Search for excess capacity on aircraft flying the required leg on lift day. Where aircraft fly the leg, examine spare load capacity and attempt to fit the lift onto an existing leg. The lift-yet-to-be-met must be met by one task leg. No spreading of load across legs is allowed yet. Where it is not obvious nor recorded that the additional load is possible, operator decision will be sought and recorded. If the lift can be met without additional tasking, update the payload on the earmarked leg, mark the lift as met and go to step 14.

10. Are there aircraft resources yet to be tasked on that day? (New aircraft are available to task until the maximum aircraft per day limit is reached.) If not available, go to step 11. If available:

(i) task one new aircraft, including task and dead legs, and reduce airframes still available for the day,

(ii) reduce lift-yet-to-be-met by the load for the new aircraft,

(iii) record spare payload capacity, and

(iv) go to step 14.

11. As there are no new aircraft available, the system will attempt to allocate extra tasking to aircraft already in the flow.

If additional tasking can be accommodated by an aircraft already tasked on the day:

(i) expand aircraft tasking to provide the new task and dead legs,

(ii) record spare payload capacity,

(iii) reduce lift-yet-to-be-met by the load for the new leg, and

(iv) go to step 14.

12. Search for excess capacity on aircraft flying the required leg on the lift day. Where aircraft are flying the leg, examine spare load capacity and attempt to fit the lift across existing legs. As lift-yet-to-be-met can now be spread across more than one leg, the algorithm essentially takes what it can get.

Where it is not obvious nor recorded that the additional load is possible, operator decision will be sought and recorded. If the lift can be met without additional tasking, update the payload on the earmarked legs and changes to task and dead legs, mark the lift as met and go to step 14.

13. Exit allocation with lift-yet-to-be-met greater than zero.

14. Exit allocation if lift-yet-to-be-met equals zero. Otherwise go to step 8.

Finalisation

15. Derive and output summary data including:

(i) aircraft committed per day with maximum and minimum highlighted,

(ii) total payload moved,

(iii) number of entities lifted,

(iv) entities moved on their preferred lift day,

(v) entities moved within their window but not on their preferred lift day,

(vi) entities struck from matching,

(vii) flying hours estimated,

(viii) flying hours not committed, and

(ix) plan feasibility or infeasibility.

16. Derive detailed plan, drawing on data from the Order of March and airlift, unit, command and location global and operation specific data files.

17. Output plan detail if desired by operator.

18. Provide electronic copy if desired by operator.

Insertion Algorithm - Parallel

The parallel insertion algorithm first commits airlift on the preferred day of lift of all entities, regardless of airlift resource limits. Simple improvements attempt to move the plan from infeasibility to feasibility. Final improvements examine alignment of tasks to improve efficiency. The operator is advised of algorithm progression and, upon completion, summary and detailed plan states.

This algorithm has best application where lift requirements clearly exceed airlift resources allocated or where airlift resource daily limits are soft (ie increases are readily entertained). Essentially, the algorithm lets entities "have their way". Iterations of airlift smoothing occur until operator satisfaction with expected airlift resource commitment.

However, where airlift resource limits are firm, this algorithm will still seek to exceed limits and processing tends to be slow. This algorithm is "the customer's friend" attempting to met all requirements on preferred days.

After sorting entities by significance, this algorithm allocates different airlift resources to all entities on their preferred lift day. Simple improvements to the plan are attempted by combining and aligning tasks on each day. Airlift resources requirement estimates are amended but the plan is not changed.

With each improvement of the plan, the system presents the expected plan state and gives the operator option to accept the state. Should the operator accept the airlift commitment expected, hard airlift resource limits will be ignored in favour of expected commitment. Final improvements then attempt to improve efficiency and dovetail tasking.

If unacceptable peaks in commitment of airlift resources remain, commitment is reviewed. For each day where airlift is overcommitted, airlift carrying the least significant entity is shifted to the nearest day where spare airlift exists and the entity's window is met. If airlift cannot meet window restrictions, the next insignificant entity's airlift is chosen. Only one aircraft task is moved per day.

Simple improvement is again performed and airlift resource requirements updated. Operator acceptance of the expected plan is again sought.

Task movement and simple improvement iterations continue until daily airlift commitments are within limits or no airlift can be moved without missing entity windows. Plan feasibility and airlift resource commitment per day are displayed to the operator.

If airlift remains unreasonably committed on some days, the operator can allow the system to relax windows. Incremental movement and improvement is again performed but without window constraints.

Having met resource limits or received operator acceptance of expected resource commitment, the system finalises by permanently applying improvements to derive a detailed plan. Each day is analysed and tasks combined where preferable. Tasks can spread into the following day provided only dead legs are flown on that day and the

agreed airlift commitment is not exceeded. Tasks are end-to-ended between days.

Finalisation produces summary statistics of the plan and an electronic form of the detailed plan.

Detailed Algorithm

Allocation

1. For each entity, allocate required tasks on preferred days. Record legs tasked and dead, payload committed per aircraft and entity lifted. Set smoothing-limits to include windows.

2. Perform simple improvements (steps 12 through 17).

3. Calculate plan feasibility and expected airlift commitment. Airlift commitment is only expected as firm alignment (ie dove-tailing or end-to-ending) and combination of tasks to form a detailed plan does not occur until finalisation. The plan is feasible if lift is met within daily airlift resource limits.

Advise the operator of the plan's present state including:

(i) plan feasibility or infeasibility,

(ii) expected airlift resource commitment per day including daily and grand totals of numbers of aircraft with full, half to full, quarter to half and less than quarter payload commitment, and

(iii) how lift was met with totals of entities and payload amounts that were met on preferred days, within windows and outside of windows.

4. Prompt for operator acceptance of plan. The operator, having been presented the expected airlift resource commitment and customer service level, decides draft plan acceptability. Acceptance suggests the following:

(i) The airlift resource commitment is satisfactory. Though the commitment may exceed daily limits sometimes, expected surges in tasking may be acceptable to airlift operators; or

(ii) Customer service cannot be reduced. Further smoothing of the plan to reduce surges in airlift will only reduce customer satisfaction. Entities moved on their preferred day and/or entities moved within their window will probably reduce.

5. If the plan is accepted, go to final improvements (steps 27 through 37).

6. If smoothing-limits already exclude windows, go to step 8.

7. If smoothing-change was not possible (given window constraints exist), advise the operator that no improvement is possible without moving entities outside availability windows. Perform step 4. If the plan is now accepted go to final improvements (steps 27 through 37). Otherwise set smoothing-limits to exclude windows and go to step 9.

8. If smoothing-change was not possible (given window constraints do not exist), advise the operator that no more smoothing is possible, given resource daily limits. Go to final improvements (steps 27 through 37).

9. Prompt the operator if smoothing of all days with expected commitment in excess of limits is required or only those days above a certain expected aircraft commitment. If an arbitrary limit is preferred, prompt for the arbitrary-aircraft-daily-limit. Otherwise set the value to zero.

10. Perform smoothing (steps 18 through 26), passing smoothing- limits and arbitrary-aircraft-daily-limit.

11. Go to step 2.

Simple Improvement

12. Start with the first day. Mark the plan as feasible.

13. Where aircraft fly identical legs on the same day and loads can be combined onto one task, combine them and delete spare legs.

14. If two tasks share destination or departure points, combine them if dead legs can be reduced. All tasks must be met on the day and aircrew duty limits observed.

15. If two tasks have either way points, departures or destinations in common, and loads can be combined onto one aircraft, combine tasks to reduce deadheading. All tasks must be met on the day and aircrew duty limits observed.

16. Record the revised number of expected airlift resources required. If this exceeds limits, mark the plan as infeasible.

17. If days remain in the plan, proceed to the next and go to step 13. Otherwise exit simple improvements.

Smoothing

18. Start with the first day in the plan. Set smoothing-change as not possible.

19. If arbitrary-aircraft-daily-limit equals zero (no arbitrary limit) and lift resources committed do not exceed daily resource limits, go to step 26.

20. If arbitrary-aircraft-daily-limit is not equal to zero (arbitrary limit imposed) and lift resources committed does not exceed this value go to step 26.

21. Choose the airlift tasking, not already marked, with the least important entity. Where more than one entity is met by a task, the most important entity is considered in the search. Mark the task.

22. Moving the entity or entities in the defined direction, find the nearest day where spare aircraft exist ie where the airlift resource limit is greater than expected airlift committed.

23. If smoothing limits include windows and the nearest day falls outside an entity's or entities' window or windows, select another candidate by going to step 21.

24. Move candidate entity's or entities' lift to new day and update expected airlift commitment.

25. Record smoothing-change as possible.

26. Increment day. If no more days exist exit smoothing. Otherwise go to step 19.

Final Improvement

27. Start with the first day. Set the plan as feasible.

28. Revise the previous day's tasking to locate aircraft tasking that finished away from home base. Home base, usually Richmond, will be defined by the operator at operation definition stage.

29. Where aircraft fly identical legs on the same day and loads can be combined onto one task, combine them and delete spare legs. Amend tasked airlift.

30. Allow the operator to define a minimum payload that any tasked aircraft must carry to remain in the matching. This removes light and effective aircraft tasking. Locate candidates tasks for removal. After receiving operator concurrence for each removal, remove task, amend aircraft commitment and record lift as not met.

31. If tasks have either way points, departures or destinations in common, and loads can be combined onto one aircraft, combine tasks if it reduces deadheading. Ensure task leg for aircraft include all legs required to meet all tasks that are now merged. All tasks must be met on the day and aircrew duty limits observed. Amend tasked airlift.

32. Perform full truck load heuristic matching of day's tasks, incorporating any aircraft starting the day away from home. Amend tasked airlift to record matching.

33. Record the revised number of airlift resources required. If this exceeds limits, mark the plan as infeasible.

34. If days remain in the plan, proceed to the next and go to step 28.

35. Derive detailed plan, using the full truck heuristic matching results and drawing from the Order of March, unit, command, aircraft and location global and operation specific data files. Provide electronic copy of plan if required by the operator.

36. Derive and output summary statistics, including:

(i) aircraft committed per day with maximum and minimum highlighted,

(ii) total payload moved,

(iii) number of entities lifted,

(iv) entities moved on their preferred lift day,

(v) entities moved within their window but not on their preferred lift day,

(vi) entities struck from matching,

(vii) flying hours estimated,

(viii) flying hours not committed, and

(ix) plan feasibility or infeasibility.

37. Output results if required by the operator.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
December 1991

3. REPORT TYPE AND DATES COVERED
Master's Thesis

4. TITLE AND SUBTITLE
IMPROVING ROYAL AUSTRALIAN AIR FORCE STRATEGIC AIRLIFT PLANNING BY APPLICATION OF A COMPUTER BASED MANAGEMENT INFORMATION SYSTEM

5. FUNDING NUMBERS

6. AUTHOR(S)
Neil A. Cooper, Squadron Leader, RAAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology, WPAFB OH 45433-6583

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GIR/LSY/91D-4

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of this research was to propose a MIS to assist RAAF strategic operational airlift planning. The present manual approach suffers deficiencies in flexibility, consistency and timeliness.

Airlift planning was first analysed and found to comprise activities of investigation, detailed static planning, implementation and dynamic planning, and review. Planning performance is measured by the effectiveness and efficiency of resulting airlift.

Automation of planning functions was investigated, especially the routing and scheduling of airlift. USAF systems, including ADANS, were reviewed and applicability to the RAAF evaluated.

A MIS is proposed that includes six development increments. It is expected to bring improvements in airlift effectiveness and efficiency through improved data management, better communications and improved decision support. 25

14. SUBJECT TERMS
* Airlift Operations, Scheduling, Optimization, Military Transportation, * Air Force planning,

15. NUMBER OF PAGES
293

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

AFIT Control Number AFIT/GIR/LSY/91D-4

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